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# Comparison between Computer Assisted Instruction as a Laboratory Strategy, and Traditional lab Instruction as Applied to Teaching Physical Science to Suburban High School Students

A Dissertation

Presented to

The Faculty of the School of Education

Columbus State University

In Partial Fulfillment

of the Requirements of the Degree

Doctor of Education

by

Marty Hayward

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**Abstract**

One of the major components of reforming today's education is the use of technology. Effective use of technology must be supported by significant investments in hardware, software, infrastructure, professional development, and support services, over the last decade, we as a nation have invested more than $66 billion in school technology (Lei, J.2010).

Educators are expanding classrooms with virtual environments and simulations, and students are seeking choices outside the brick and mortar school building, even opting to take the entire class online. This trend aligns with this research due to the laboratory experiences being moved to an online format. This research will compare the use of technology in the form of supplemental virtual labs and simulations to traditional direct lab instruction, as measured by the students' achievement on benchmark tests.

This research will add to the existing literature by providing data comparing technology as a supplemental strategy, to traditional instruction by measuring any differences in academic achievement as measured by benchmark testing.

The findings suggest that there is no statistically significant difference between students who learn using virtual simulation compared to those who learn using traditional lab instructions. Similarly, there are no statistically significant differences explained by gender and ethnicity. The study established that virtual simulation and traditional lab instructions both have strong points that are beneficial to the science learners. Further research, therefore, needs to be conducted on how the two approaches can be brought together into a complementary relationship.

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## Introduction

American education is viewed as being average when compared to other leading countries. Finland has the top ranked educational system in the world. Over half a million 15-year-olds around the world were given the Program for International Student Assessment, often used to test the state of education in the global arena. The last test was taken by students in 2012, and it is given every three years utilizing math as its focal point, but also incorporates smaller sections that include science and reading. The results showed that the US was trailing behind educational giants like Korea and Finland (Kena, 2014).

One of the major components of reforming the current educational system is an increase in the implementation of technology. School systems are making significant investments in technology and are expecting results commensurate with the level of investment. The investments take the form of professional development and training, software, support services, hardware, and infrastructure. Over the last decade, over $66 billion has been invested in school technology (Lei, 2010). Over the past 20 years, schools have spent increasing amounts of their funds to acquire items like computer equipment, services, related supplies and software (Pelavin, 1997). The increased investment in technology has raised the public's expectation for a substantial return on this investment. School reports are continuously reviewed and compared and reported in the media. Educational stakeholders are seeking evidence of the cost effectiveness of these expenditures on technology in K-12 schools (Ringstaff & Kelley, 2002).

Technology is currently a common element in the lives of many learners in the United States of America. Many school systems around the world have incorporated technology as a

teaching and learning tool in their curriculums to provide opportunities for both students and their teachers to become comfortable with the use of technology (Murphy, DePasquale, & McNamara, 2003). On the other hand, however, some stakeholders in the field have become skeptical about the use of technology for instructing learners. Some of the concerns that led to this skepticism are students may miss out on the central experiences that are necessary for mental development and the costs for incorporating technology into education may well exceed the benefits realized.

These concerns may be genuine, but it is evident that some advances in the sector of virtual education may help the concerned individuals to rethink the potential of using technology in the classrooms (Murphy, DePasquale, & McNamara, 2003). According to Kozma (2003), research findings indicate that some features of new technologies are consistent with the principles that guide the science of learning. Such findings hold a promise for the improvement of the state of America's educational systems, and elsewhere in the world. However, stakeholders remain concerned that virtual instruction does not automatically translate to positive results in the classrooms.

Positive results rely heavily on how the instructors apply information and communication technology within the learning environment. Against the Traditional Methods of Instruction, Educational Technology is viewed as a better approach for the change of pedagogy and curriculum (Kozma, 2003). Educational technology, therefore, is adopted by many countries as part of an instructional transition towards teaching and learning methods that are constructivist in nature. This constructivism comes in the context of the sector of education aiming to improve or reform the current instructional approaches (Murphy, DePasquale, & McNamara, 2003).

Some educationalists postulate that there is limited evidence to indicate that virtual instruction and online learning, improve the outcomes for students. Digital distractions and unequal access to technology are additional reasons for concern regarding the efficacy of virtual instruction methods. These are factors that can lead to wide gaps in achievement by learners. State and federal lawmakers have expressed conflicting views regarding the benefit offered by increased technology in education. There are new challenges resulting from ever-evolving technologies. For example, questions about how learning institutions can privately and securely handle learners' personal information have risen due to the increase of what is now universally known as "big data" (Kozma, 2003).

Virtual learning may have more appeal to individuals who consider the educational challenges faced by learners with special needs. Adaptive technology and virtual and online learning technologies may be more effective for learning populations where traditional instruction methods have not allowed access to information. Virtual technologies can be designed specifically to address issues of access in certain learning populations. Students with special educational needs may receive information more effectively and may be evaluated more appropriately due to adaptive and other technological applications. Virtual instructions could be a powerful means of filling instructional voids, however, no matter the learning population, the technology must engage students and it must impart relevant information. Such engagement needs to be meaningful and intellectually authentic to ensure that the objectives of the curriculum are achieved.

Kozma (2003) stated that virtual instruction could prove effective for language instruction and to enhancement of the participation of learners with special needs. To effectively use technology and achieve positive results, teachers must review their curriculums

and establish instructional goals consistent with the curriculums. In order to use increased technology in the classroom, the technology must be readily available to teachers and students and designed to achieve the instructional goals set for the students.

Educators are expanding classrooms with virtual environments and simulations, and students are choosing learning methods other than instruction given in brick and mortar school buildings. Some students even opt to take entire courses on line. This trend aligns with this research because even clinical and laboratory experiences are transitioning to online formats. This study compared the use of technology in the form of supplemental virtual labs and simulations to Traditional Method of Instruction, by measuring student achievement. This research added to the existing literature by providing data that compared technology as a supplemental strategy, to traditional instruction. Benchmark testing was used to identify any differences in academic achievement prior to the implementation of the study.

**Statement of Problem**

Educational policy in the United States is trending toward increasing technology but there are conflicts in the results attributed to the increased technological implementation. Policymakers have not measured the effectiveness of technology through the use of performance benchmarks that offer control to the outside variables, such as prior student content knowledge, or reading level. Therefore, technology may or may not be a useful tool for every student. The problem was that despite significant investments in instructional technology, following the assumption that it was effective in supporting student learning, little research analyzed the effects of technology using benchmark testing. Thus, there was the need for research on the effectiveness of technology, especially when it was used as a supplemental teaching tool. There was very little data comparing benchmark testing outcomes from Traditional Method of

Instruction (TMI) vs. the Computer-Assisted Instruction (CAI). There was a need to conduct an analysis of student achievement data that offered a direct comparison between the two types of laboratory instruction.

**Purpose of the Proposed Study**

The researcher proposed to analyze whether the use of technology while keeping pre-achievement controlled, produced any significant differences in students' achievement, as measured by benchmark testing. This research sought to generate data measuring the efficacy of technology in the physical science classroom. The results and conclusions from the study were useful for the development of instructional delivery models and generating data for future policymaking decisions.

The results of this study supported the pedagogy technology model of instruction in science education, and thus provided a basis for recommendations to expand such instruction. This outcome was informative to the district-developed curriculum and instructional strategies. Using the results that were obtained from this research, curriculum leaders could increase the level of student achievement by using data to guide the policy, budget, and instructional planning. Eliminating unsuccessful teaching practices should improve the teacher delivery model.

The results of the study were shared with the National Science Teacher Association. The NTSA connects science teachers all over the country. The ultimate contribution would be an increase in academic achievement for all students. These results provided new insights and information to the science community.

## Significance of the Study

This research was necessary as it added to the literature by measuring the effectiveness of supplemental laboratory instruction in a selected suburban physical science classroom. This was important to the community of educators, because it provided data on the effectiveness of Computer-Assisted Instruction (CAI) and, therefore, helped provide data highlighting the differences in achievement according to gender and ethnicity. The computer delivering the simulation was one factor, but how students respond to the delivery model was another consideration.

The results of this study held significance beyond the classroom that was the site of the research. The results of this study may be extended to the district level as a basis for instructional and budgetary decisions, or as a basis for future studies in this area. The analysis of various CAI programs could be helpful for stakeholders, and this research provided a foundation for that knowledge. Above all, the importance of the research lies in the direct comparison between TMI and CAI as supplemental instruction and comparing the two pedagogies by benchmark testing.

## Research Questions and Hypotheses

Considerable research indicates that CAI can result in a positive impact on the learning capabilities for students of all ages in a variety of content areas, indiscriminately. However, the research is biased towards the virtual labs/simulations in the science classroom. Therefore, the primary question was:

Is there a difference in student achievement between students who are taught using Computer-Assisted Instruction (CAI) as a laboratory strategy in a selected tenth-grade physical

science course, as compared with tenth-grade students who are taught using Traditional Method of Instruction (TMI), as a laboratory strategy?

This broad question was then further divided into three sub-questions to gather accurate data that provided additional insights into the possible correlations. These questions and their respective hypothesis were given as follows:

**1.** How did the results of the unit benchmark test differ between students who received supplemental CAI through the use of virtual simulations and labs and students who received only TMI, after controlling for pre-achievement test scores?

$H1_0$: There is no difference in achievement on unit benchmark test between students receiving supplemental CAI through the use of simulations and labs and students who receive only TMI, after controlling for pre-achievement test scores.

- DV: Achievement
- IV: Instruction type (virtual labs/simulations and Traditional Method Instruction)
- Covariate: Pre-achievement
- Statistical Analysis: ANCOVA

**2.** Was there a difference in achievement on the unit benchmarks between students receiving supplemental CAI through the use of simulations and labs and students who received only TDI, after controlling for pre-achievement test scores, moderated by gender?

$H2_0$: Differences in achievement on the unit benchmarks between students receiving supplemental CAI through the use of simulations and labs and students, who receive only TMI, after controlling for pre-achievement test scores, are not moderated by gender.

- DV: Achievement
- IV: Gender

- Covariate: Pre-achievement
- Statistical analysis: ANCOVA

**3.** Was there a difference in achievement on the unit benchmarks between students receiving supplemental CAI through the use of simulations and labs and students who received only TMI, after controlling for pre-achievement test scores, moderated by ethnicity?

$H3_0$: Differences in achievement on the unit benchmarks between students receiving supplemental CAI through the use of simulations and labs and students, who receive only TMI, after controlling for pre-achievement test scores, are not moderated by the various categories of ethnicities (Hispanic, Caucasian, African American, and Asian).

- DV: Achievement
- IV: Ethnicity (Hispanic, Caucasian, African American, and Asian, or Other)
- Covariate: Pre-achievement

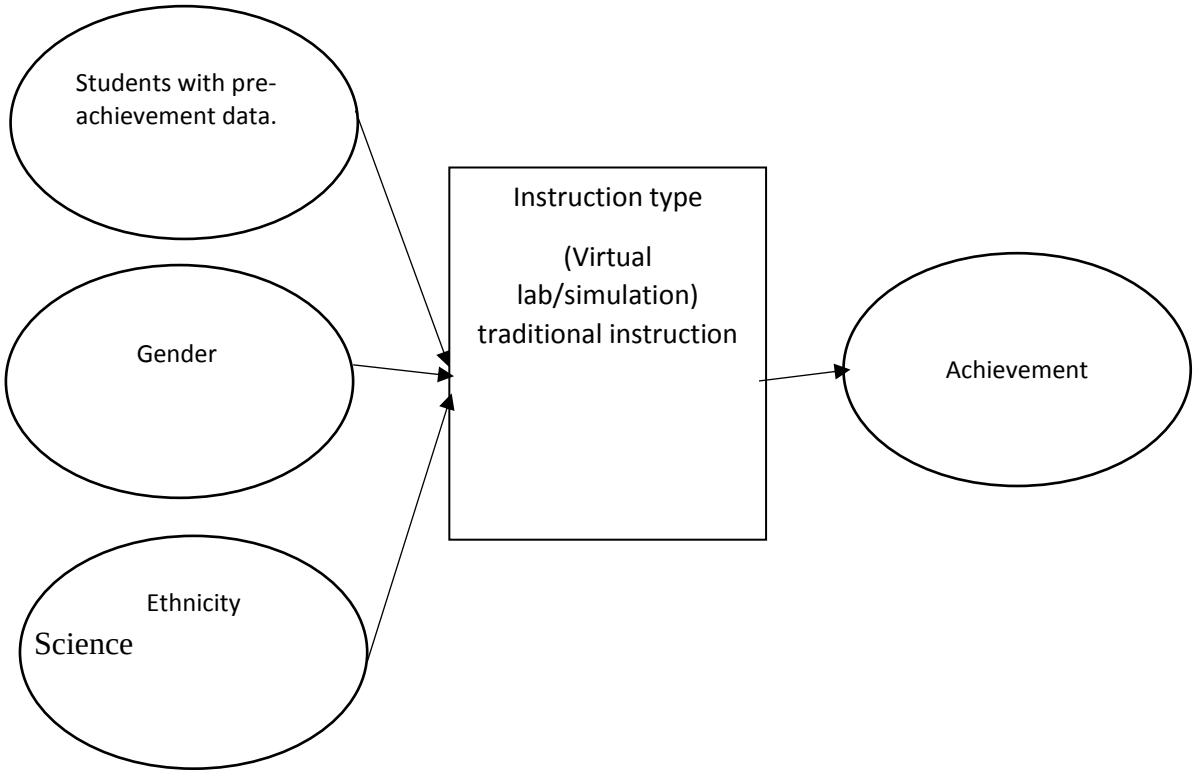
**Statistical analysis: ANCOVA**

**Table 1**

***Hypotheses and Related Methodological Factors***

| Hypotheses | Dependent variable | Independent variable | Covariate | Statistical analysis |
|---|---|---|---|---|
| H1 | Achievement | Instruction type | Pre-achievement | ANCOVA |
| H2 | Achievement | Sex | Pre-achievement | ANCOVA |
| H3 | Achievement | Ethnicity | Pre-achievement | ANCOVA |

**Conceptual Framework**




**Procedures**

This study involved the use of a quantitative quasi-experimental research design. This study was a direct comparison of CAI supplementing direct instruction and TMI. The study used benchmark testing to directly compare students as they moved from their experimental group into their own control group. The proposed design included an existing group of participants who functioned as a control group that received only TMI, then as a treatment group that received CAI that consisted of virtual lab/simulation instruction. Both groups received three instructional units, taught with TMI lab instruction, and three taught with CAI lab instruction. A

covariate analysis was used to measure differences in the academic achievement of each group, and to determine whether sex or ethnicity were modifying variables.

Ethical values in this research were necessary. All personal and identifying information was kept confidential by the researcher, and all results presented only in aggregate form. Similarly, there was no prejudice or bias against any individual or teaching method. The study procedures and data management procedures acquired their approval from the Columbus State University's Institutional Review Board and the cooperating school.

Parents of all students eligible to participate in the study received an informed consent form that outlined the purpose of the study, the design of the research, and provided assurances about the risks and benefits of allowing their child to participate. Parents were assured that their children would not experience any harm and that the children were at liberty to withdraw, or they could be withdrawn from the study without academic penalty. Parents gave written permission for their children to take part in the study.

**Population, sample, and sample size.**

The population consisted of approximately sixty (60) tenth-grade students in a suburban high school. The groups were adjusted according to the number of students who had parental permission to participate in the study. The sample in each group reflected the larger population of the school. The study occurred in the researcher's physical science classroom. This gave an approximate experimental sample size of 50 students and a control group of 50 students, assigned by class registration.

**The significance of ANCOVA**

ANCOVA (Analysis of covariance), expounds more than the ANOVA (Analysis of variance). The extension is noted on the grounds of statistical control and power that ANCOVA has when compared to ANOVA. An overview of ANCOVA takes note of the fact that, in this study, the statistical control of the linear effects of a variable are made possible. ANCOVA employed the use of both ANOVA and regression to control the variables that are extraneous. It is critical to understand that the linear effects as above mentioned include those variables that a researcher has controlled in his study.

ANCOVA is administered to a data set where it tests for the effects of the primary variable and the interaction variables while having a continuous dependent variable. The analysis of covariance is one that is applied to data to examine the primary variable and the interaction effects of the variables that are said to be categorical, on a variable that is supposed to be dependent. The analysis also takes note of the continuous variables which tends to co-vary with the dependent variable. A covariate, at this juncture, is what a control variable defines. ANCOVA had a critical role in the study since it helped control for the effects of pre-achievement that had been selected as the variable that may have been co-varying with the dependent variables. The ANCOVA method, therefore, brought definite benefits to this research as far as statistical control and statistical power is concerned.

The use of ANCOVA in this study was significant because it provided the room for conducting a statistical control of the effects of variables. ANCOVA allowed for the removal of the covariates from the potential explanations of variance that had an effect on the dependent variable. Statistical techniques and not direct methods, served the purpose of controlling the extraneous variable, were applied to the study to facilitate the control as mentioned earlier by

partitioning any effects attributed to the existent variation owing to the presence of the covariate. The importance of this is that the researcher would be in a position to carry out the investigation that is associated with the primary independent variable. The logic that rested with the statistical control function of the covariate function of ANCOVA is that the desired control in the study would be brought out. The covariate assumed this role by simply adjusting the mean of the group on the dependent variable. As a result of providing adjustments to the dependent variable, members within a group are adjusted around a common mean. ANCOVA would be in a position to offer the most reasonable estimates on how the comparison groups would have turned out if they had identical means on the control variable.

Secondly, the covariate's significance in an ANCOVA study is the fact that it can reduce the chances of a type II error. This significance is entirely possible when the primary variables are used or when comparisons are used. In this case, the comparisons are made within either post or planned investigations. Type II errors are related to the statistical power, in an inverse manner and so the significance of the covariate as a component of ANCOVA is critical to this study because the statistical power of the study would be enhanced and as a result, the rigor, quality and validity of the study would be maintained.

The ANCOVA also helped with the adjustment of the preexisting differences in various nonequivalent groups. The method made it possible for the researcher to make corrections in the initial group differences before assigning the groups. ANCOVA additionally helped the researcher in conducting homogeneity of variance (Levene's test) of equality among the groups. The method gave the researcher the opportunity of estimating the effect of one continuous variable, that is, instruction on a particular outcome such as achievement. It was significant in the adjustment of the factors that were thought to modulate the relationship between the continuous

variable and the outcome. The factors that ANCOVA helped in modulating were ethnicity and sex.

**Ensuring the significance of ANCOVA**

The statistical method used in a study must be effective to address the needs of the study. With that idea in mind, ANCOVA had to be effective for the researcher to tap the full significance of the study. Careful selection of the covariate would make a difference towards being a step closer to achieving the research effectiveness. One way to ensure the careful selection of a covariate would be by making sure that the independent variables had no effect on the covariate. Second, ensuring that the covariate is related to the dependent variables linearly would result in the reasonable selection of the study covariate identified in this particular study.

**ANCOVA's Assumptions**

It is critical to understand other factors that are important to an ANCOVA, while addressing the significance of ANCOVA, in any given study. The place of assumptions in ANCOVA is crucial, the assumptions in ANCOVA are connoted to the relationship between the covariate and the dependent variable. There is the assumption of independence where the case representation is of random variables which are independent of each other. The second assumption is that of normality where the distribution of the dependent variable is said to be normal, in any given value of the covariate in the population or for one level of the factor of the independent variable. Finally, the third assumption is that of the homogeneity of variance. Under this assumption, in the conditional distribution, the dependent variable variances are equal. This assumption can be checked by the Levene's F test as a follow-up test procedure.

These assumptions provide the basis for a blueprint in an ANCOVA and this study particularly, the assumptions aided in ensuring that the ANCOVA was efficient and that the study maintained the elements of validity, rigor, and quality as mentioned earlier. The features as indicated earlier prompted the significance of the study as far as analyzing both the statistical power and the statistical control of ANCOVA.

**Definitions:**

Databases: Comparisons of each group's mean score on the Criterion-Referenced Competency Tests (CRCT) will be used to determine the pre-achievement for each participant. The CRCT is a Georgia statewide benchmark test given to middle school students every year. This test will be used to identify outliers within the two groups.

Computer-assisted instruction (CAI): CAI is instruction using the computer to give direction through slides, tutorials, and simulations to guide the instruction (Thomas 2013).

The Program for International Student Assessment (PISA): PISA had its design done by the Organization for Economic Cooperation and Development to evaluate matters concerning the quality, efficiency, and equity of school systems, globally. The PISA has assessed 15-year-old students on the topics of reading, mathematics, and together with literacy, since 2000, on a 3-year cycle (Perry 2015).

Traditional Method Instruction (TMI): Traditional classroom teaching focuses on face to face lectures in a synchronous environment. The instructor uses textbooks and handouts, and the delivery model is teacher directed (Chi-Cheng, 2014).

**Delimitations**

The scope of this project was limited to one school, in one suburban Georgia school district, in one physical science classroom. This narrow sample size was selected so that the

researcher could monitor the study on a daily basis. Due to class registration assigning students to the class, this research could transfer to the larger population of any school with similar demographics.

A quantitative design was proposed to reduce complexity and ensure relevance of findings. The study focused only on tenth-grade students at a selected school in the Henry County school district. The research did not involve psychologically based testing to analyze the effects of CAI or TMI as a preference for the learner. The study simply compared students' achievement on a series of the benchmark test. The study revealed no general conclusions concerning CAI instruction as this work focused on the results of the virtual lab/simulation software delivered by CAI the platform.

**Limitations**

The design of this study was not assumed to reveal broad conclusions concerning CAI, as this work focused on the results of only virtual lab/simulation software delivered by CAI. Conclusions about the effectiveness of this particular dimension of CAI were not assumed to generalize to other forms of technology integration. Also, the results of this study did not necessarily generalize to other science courses unless the demographics and software were very similar. The small sample size limited the ability to draw broad conclusions about CIA concerning TMI but provided a basis for future research that may be more generalizable. The short duration of the study may have concealed results that may have emerged if the experimental period was longer.

It should also be noted that as a quantitative study, the reasons behind a correlation or a lack of correlation was not be explained. The results only stated the presence or absence of correlation, and future research will have to explore any possible explanations.

**Summary**

Chapter 1 presented an introduction to the problem that provided the basis for this study. Educators and policymakers at all levels have made significant investments in instructional technologies on the assumption that the integration of technology will support enhanced student learning. (Ping, Lem, 2013). However, the literature revealed inconsistent results about the efficacy of CAI in enhancing student achievement (Tienken, C, 2008). There was, however, a stronger base of research that supported the integration of technology in the sciences, because the inquiry-based nature of science instruction supported the use of CAI in unique and pedagogically sound ways (McPherson, M, 2008).

The purpose of this quantitative quasi-experimental study was to examine whether or not there was a significant difference in student achievement between students who were taught using CAI in a selected tenth-grade science course, as compared with the same tenth-grade students who were taught using TMI, as measured by benchmark testing. Also, gender and ethnicity were explored as variables that may have moderated any differences in student achievement between both methods. The results of this study provided insights into how best to enhance existing models of high school science instruction while also providing a basis for future research in this, particularly error.

# Literature Review

## Introduction

Computer-assisted instruction is known by a variety of names, including computer-assisted learning, computer-aided instruction, and technology enhanced learning (Johnson, Perry & Shamir, 2010). This type of instruction can include a wide variety of media such as streaming video, animation, images, audio, and text. There can also be technologies including CD-ROMs, satellite TVs, audio and video feeds, the Internet, communication systems, local networks, or intranets. While the focus here is on the use of the technology in a science classroom, it can be used in a wide variety of other circumstances (Larwin & Larwin, 2011).

The personal computer and the Internet have resulted in significant changes in society (Thomson, 2011). The digital networks in electronic communications which are now possible have transformed the way people are entertained, interact, and work. This rapid change in society, secondary to advances in technology has resulted in increased opportunities and a new need for learning new skills. As a result, there is now a need to change the information transmission model used in education (Gürbüz & Birgin, 2012).

While society has widely adopted communications through the computer, there has yet to be a complete transformation with regard to learning (Chapelle, 2010). The world is in a developmental phase with the transformative medium of digital technology and communications. The impact on education from this transformation has yet to be fully experienced. Computer-assisted instruction is still in its early stages, and the inherent capabilities of this approach are in their early forms (Thomson, 2011). The advantages of computer-assisted learning are

compelling and have encouraged a reconceptualization of learning and teaching transactions. However, due to a lack of complete understanding of the new learning ecology associated with digital technology, education has not yet fully embraced the benefits in this approach (Veneri, 2011).

Computer-assisted learning is not just a new technology which can be added to the educational system or rejected (Owusu, Monney, Appiah & Wilmot, 2010). Instead, it represents a different category or mode of the communication which occurs between teachers and their students (Vera, 2012). It also has changed the way in which students interact with each other. Due to communication being the basis for educational encounters, digital technologies will impact the entire system resulting in significant changes (Mazzotti, Test, Wood & Richter, 2010). Computer-assisted learning is not the most efficient approach to simulate or replicate the traditional classroom learning. This would involve simulating the conventional approach which is based on a different type of learning ecology than that of computer-assisted learning. This would likely result in learning experiences being lost as well as an inability to capitalize on the unique aspects of computer-assisted learning (Kelley, Bartholomew & Test, 2013).

Computers and digital technology will most likely transform many types of learning and the education which occurs during the 21st century (Thomson, 2011). Until recently, the influence of computer-assisted learning in many educational institutions has been relatively small compared with the changes taking place in the broader society (Selwyn, 2011). Many approaches have been merely enhancements of the current education strategies. It is likely that as society, and educators gain a clearer understanding of the strengths and potentials of computer-assisted learning; there will be a more effective transformation of the learning transactions and educational approaches (Chapelle, 2010).

Computer-assisted learning can be an open system (Larwin & Larwin, 2011) with the software interacting with the student and changing the lesson and information provided as necessary. With the use of the World Wide Web, the learning and teaching transaction experiences involve unparalleled access to vast amounts of information. The level of information can be a powerful attractor to both learners and teachers. Nevertheless, working with this nearly unlimited amount of information is not always efficient or effective (Vera, 2012). The openness of the Internet creates exposure of students and educators to a wide range of ideas and perspectives that may not be consistent (Mazzotti et al., 2010). This means there must be a stabilizing influence which limits the way in which the information is presented. This blending of information from the online platform and traditional classroom provides an opportunity for educators to help students make sense of the vast information stores which are now available. Furthermore, educational institutions can help students experience a sense of purpose and community, which makes learning a sustainable practice (Owusu et al., 2010).

**Evolution of Computer-Assisted Instruction.**

There are a number of assumptions which impact computer-assisted instruction which may be incorrect (Rennie & Morrison, 2013). For example, the assumption that higher education is a group of learners who are dedicated to reaching learning outcomes of a higher order. This can be viewed as a type of rhetoric rather than the actual situation. It is not always the case that 21st-century higher education has a goal of encouraging students to approach their learning in a critical fashion or process the information provided in a meaningful and deep way (Eom, 2011).

The personal computer became more widely available during the 1980s (Wankel & Blessinger, 2012). There were increasing numbers of individuals who could afford the new

technology. During the 21st century, it has become an essential part of interfacing with the World Wide Web and the Internet (Selwyn, 2011). The personal computer has transformed learning and created a new portal for teaching. Society is generally at the beginning of understanding and discovering the extent that new technologies will change expectations and approaches to education (Eom, 2011). These novel technologies represent a qualitative shift in education and learning. Communication technologies have become ubiquitous in many forms. These communications are now available in voice, visual, text, and a variety of combination and other forms (Vera, 2012). The communications technologies of the 21st century have elicited a paradigm shift which is not yet been fully realized (Wannemacker, 2011). One of the most profound influences on society and education has been online learning, which is sometimes referred to as e-learning. This is an educational method which makes it practical to engage in collaborative learning, which is asynchronous (Garrison & Vaughan, 2013). Collaborative learning means that the students are interacting with each other and the teacher to master new material. The communications can be done through emails or digitally recorded lectures. This means the teacher and students do not need to be on the same schedule. This is known as asynchronous communication.

The technological developments occurring in the last decade have required educators to re-examine how learning occurs and should be approached (Keppell, 2012). They also are required to understand how novel learning outcomes are necessary and possible. The advent of global communications combined with intimate learning communities will result in enhanced opportunities for knowledge development, which is cross-cultural (Wankel & Blessinger, 2012). Global communications allow people from nearly anywhere in the world to communicate with each other. This is usually done over the World Wide Web with technology such as email and

chat rooms. The intimate learning community is one in which there are fewer students per teacher and there are more frequent student-teacher interactions. There are also more interactions between the students.

Knowledge is becoming increasingly important in the global economy. This means greater value is being placed on advanced learning and thinking abilities (Pachler & Daly, 2011). The challenge is one of turning digitized information into knowledge for people. Instead of being conceptualized as a technical problem, the challenge can be viewed as social and educational in nature (Lin, 2011). The solution is within the realm of integrating teaching approaches with the novel technological enablers arising in the 21st century. Computer-assisted learning lies at the intersection of these factors. It can allow for rich communities of education, which are available at any place, during any time, and can involve asynchronous communications (Garrison & Vaughan, 2013).

**Supporting Studies**

| Authors and Date | Type of Study | Findings of the Study | Subjects' Gender | Subjects' Ethnicity |
|---|---|---|---|---|
| Attaran, M. (2007). | Literature review | Collaborative computing is well-established. | N/a | N/a |
| Chapelle, C. A. (2010) | Discussion paper | Computer assisted language learning can be difficult to distinguish from other language materials due to it being spread throughout many language curricula. | N/a | N/a |
| Gürbüz, R., & Birgin, O. (2012) | Experiment | Computer-assisted teaching is more effective than the traditional methods for changing student misconceptions. | Both | Not reported |

| Authors and Date | Type of Study | Findings of the Study | Subjects' Gender | Subjects' Ethnicity |
|---|---|---|---|---|
| **Johnson, E. P., Perry, J., & Shamir, H. (2010)** | **Experiment** | **A sequencer is important for presenting computerized reading to young children.** | **Both** | **Not reported** |

Another assumption which is questionable is that technology is merely a method for transmitting information (Brouwer & Dekker, 2013). This is most likely an overly simplified approach and does not account for the capabilities, characteristics, or potential that computer-assisted learning provides. Instead, these rapidly advancing technologies require that there be a fundamental redefinition in the way learning and education is approached (Lin, 2011). The activities of students and educational design are of crucial importance. Nevertheless, the type of communication available has a significant effect on the possibilities for education (Jin & Lin, 2011). This reality is obvious when various types of distance education are used such as videoconferencing and electronic correspondence (Selwyn, 2011). Email involves written communications, which are asynchronous and relatively slow. The videoconferencing is a form of visual and verbal communication, which is synchronous and sustained. Therefore, computer-assisted learning can support both asynchronous and synchronous communications in a variety of formats (Vera, 2012). The educational advantage of this variety is the capacity for supporting text-based interactions, which are reflective and independent of the factors of distance and time (Wankel & Blessinger, 2012).

While computer-assisted learning has attracted a significant amount of attention, its adoption has exceeded how well the technology is understood within an educational perspective

(Bates & Sangra, 2013). The value of this technology is not merely quicker access to vast amounts of information, but the capacity to facilitate thinking and communication, which allow for the construction of knowledge and meaning. It is not surprising that research into the use of computers for educational purposes often does not indicated significant differences in learning outcomes from traditional versus technically advanced approaches (Selwyn, 2011). One would not expect there to be a difference if the same teaching activity is occurring. Merely changing the medium used for the communication is not sufficient to enhance learning outcomes (Rennie & Morrison, 2013).

The various communication technologies have weaknesses and strengths (Pachler & Daly, 2011). There is a cost associated with any communication medium when the experience is restricted or enhanced, distorted or clarified, and concealed or revealed. The majority of online learning does not make full use of the multimedia opportunities available in a digital environment. For example, there is often a tendency to use only one form of learning rather than a combination. Information may be provided in the form of a video, but this is not reinforced with text, or vice versa. Educators have failed to understand and take advantage of the blending of symbol systems, which can be accomplished through multimedia and the text-based communication systems (Wannemacker, 2011). New methods of communication and expression are made available by this technology. During the second decade of the 21st century, many people are so familiar with computers and communication technologies that they are unaware of the many possibilities, which have not yet been explored (Bates & Sangra, 2013).

It is impossible to take full advantage of computer-assisted instruction without appreciating its gains and losses (Quinn, 2012). Technology can shape the way in which the world is experienced. Computer-assisted learning is not merely another tool. It has the

capability of changing the way students, and teachers understand and experience learning. The time for the realization of this shift in its full impact is not yet known. It is also not yet been established what force will result in shifting the use of computer-assisted learning in fundamentally novel ways (Vera, 2012). These new approaches are likely to result in qualitatively different and enhanced shifts in learning outcomes and processes. This will allow students and teachers to go beyond the mere access of information. There is now more than sufficient access to data. The challenge has become understanding and navigating these vast amounts of information (Brouwer & Dekker, 2013).

Computer-assisted learning has a nearly unlimited potential for expanding education horizons (Quinn, 2012). In order for this potential to be realized, the assumptions associated with computer-assisted learning must be overcome. It is these erroneous assumptions which limit the further development, financing, and research of this type of learning. It should be remembered that generally, institutions of higher learning are not creating communities, which are committed to meaningful learning outcomes or critical discourse. Educational approaches need to be re-examined in order to appreciate the capabilities provided by new communication technologies (Wannemacker, 2011). These technologies have the capability of enhancing the quality of learning outcomes (Pachler & Daly, 2011).

**Advantages**

The advantages of computer-assisted learning go beyond unlimited access to information (Kalet et al., 2012). The approach provides interactive and communicative features for learning, which were previously unavailable. The goals of successful computer-assisted learning blend cohesiveness with diversity resulting in a learning ecology which is both dynamic as well as

intellectually challenging to students. The interactivity surpasses a one-way transmission of information and extends to the student's thinking regarding how communications occur between human beings when engaged in an educational endeavor (Chapelle, 2010).

Prior to the advent of personal computers, digital technology, and the Internet, an increase in learner independence means that there was more isolation and less collaboration (Kalet et al., 2012). In more traditional education settings, collaboration and independence were negatively correlated. When there was increased collaboration, there was less independence and vice versa. This was because independent studies meant the student was working on a personal project such as a master's thesis or doctoral dissertation. The student usually worked alone and there was little interaction or collaboration with others. Computer-assisted education goes beyond these limitations (Gürbüz & Birgin, 2012). The approach makes it possible for students to experience freedom as well as being part of a learning community (Jin & Lin, 2011). The computer-assisted approach recognizes as well as integrates both public and personal aspects of the educational experience. For example, students may work independently in order to gather information on a certain topic. They can then be asked to pool their resources as a group and develop a presentation which uses the information gathered by those involved (Veneri, 2011).

In order to take advantage of computer-assisted learning as a cohesive system which is open, it is crucial that the pedagogy be re-examined (Larwin & Larwin, 2011). Education will become less about recalling facts and ideas and focus more on the process of thinking critically. Traditional education often fails to provide students with experiences for developing self-direction and critical thinking, which are necessary to the experience of lifelong learning. Often the conventional education outcomes are substandard, and many individuals find it difficult to adapt to the 21st century (Jin & Lin, 2011). The traditional education which involves objective

testing and standardized learning is many times experienced as cold and unemotional (Owusu et al., 2010). The teachers' lecture provided information but did not encourage students to think critically or fully grasp the application of the ideas. The transformative power of computer-assisted learning lies in its capacity to increase the value of learning through providing a means of helping students grasp information and think critically about it. This means the computer-assisted approach goes beyond the more passive transfer of information involved with traditional learning (Kelley, Bartholomew & Test, 2013).

Computer-assisted learning can both support and enhance current teaching practices (Korucu & Gunduz, 2011). However, the most important impact is likely to be allowing for new approaches of recognizing and engaging a learner's capability for interaction (Kalet et al., 2012). The learner can experience independence while being part of a learning community. In fact, collaboration and autonomy can make up the primary elements for a qualitative and unified shift in the learning process (Korucu & Gunduz, 2011).

In order for computer-assisted learning to be successful, it must be more than a method of accessing significant amounts of information (Kelley, Bartholomew & Test, 2013). There is now growing recognition that merely having the necessary information is not sufficient for learning to occur. The way in which the educator designs the experience for students and the social interactions are important for the learning transaction to be successful (Selwyn, 2011). Quality education includes the integration of context and content in a dynamic manner which is facilitated by a educator who is pedagogically competent (Johnson, Perry & Shamir, 2010).

**Salmon's Five-Stage Model**

During 2000, Gilly Salmon co-authored a book titled *E-Moderating: the Key to Teaching and Learning Online* (Salmon, Nie & Edirisingha, 2010). Salmon explained her five-stage

model of computer-assisted learning, which was developed through her action research regarding computer mediated conferencing and on-line learning. During 2011, the third edition of his book was published. Salmon provides a pragmatic model which can be adapted to a variety of computer-assisted learning contexts. Blended learning occurs when traditional approaches to teaching are combined with computer-assisted techniques (Gash, 2012).

Salmon's most-recent iteration of the five-stage model of learning includes access and motivation, online socialization, information exchange, knowledge construction, and development (Vrasidas, 2013). Each of these stages requires that the learner master various skills and builds upon these as they progress through the learning experience. The educator supports learners along their journey through using a variety of techniques (Gash, 2012).

The first stage in the model includes access and motivation (Berge, 2013). During this stage, the educator provides support and allows for a sufficient time to let the learners gain access to the course information. It is important for the educator to maintain motivation during the first stages so that the learners are not discouraged from putting forth their best-effort. During this initial stage, the interaction between the students is limited (Salmon, Nie & Edirisingha, 2010).

The first stage of Salmon's model frequently involves the student gaining access to the school system, establishing passwords, and deciding on a username (Gash, 2012). They may also need to locate the spaces of online learning in the necessary modules for the learning experience. It is during this stage that they familiarize themselves with the communication tools and course information. It is important that the educator creates an environment that enables learners to feel encouraged, reassured, and welcome. The teacher must also ensure that the students can gain access to the necessary learning materials as well as how to gain technical

support when needed. Learners must understand the rationale of using an online learning space. Sufficient time must be provided by the instructor to ensure that the learners become comfortable within the learning environment (Vrasidas, 2013).

During the second stage of Salmon's model, the students begin to socialize online (Gash, 2012). The educator should encourage the learners to meet one another. Even though the students may have already met in the traditional school setting or classroom, they should still be reintroduced in the online environment. Many times, students will have different confidence levels or even personas in the virtual versus real-world (Jin & Lin, 2011). Students who are relatively confident in a traditional classroom may have less certainty in the online environment. Of course, the opposite can be true as well (Berge, 2013). Some students will feel more confident in a virtual environment than in a physical setting.

The second stage of Salmon's model includes the learner interacting with others taking the course and establishing a virtual identity (Berge, 2013). The educator facilitates this stage through providing the students with opportunities to interact. The educator should also ensure that the learners understand it is important to have social connections with their peers in order to experience enhanced learning (Salmon, Nie & Edirisingha, 2010).

The third stage of Salmon's model includes the exchange of information (Berge, 2013). Once the learners are communicating with one another, they can be encouraged to share the information through continued connections and relationships. The information exchange is often experienced as pleasant as well as beneficial. However, it can also be an overwhelming experience if there is an oversupply of information and the learner is unable to discern what is useful (Lin, 2011) is. For this reason, it is important that the educator have an online presence and is available for direction and guidance (Veneri, 2011). During this third stage, the learner

will be engaging with the course content through interactions with the educator and fellow learners. The learners are likely to benefit from the mutual exchange of course information which is relevant. The learners will need to develop individual strategies for minimizing information overload (Wannemacker, 2011). They will also have to identify the information which is likely to be most useful for their personal situation (Vrasidas, 2013).

During the third stage, the educator will be facilitating information exchange (Berge, 2013). This is done through providing the learners with instructions on how to most effectively use the online spaces of communication. This may involve common rules of Internet etiquette (Jin & Lin, 2011). For example, one should not send emails or other messages which are in all capital letters as this is equivalent to screaming. Also, one should respect the privacy of others and never forward personal emails without the author's permission. The teacher will frequently need to encourage the learners as well as provide directions for participating in the necessary learning activities. It is important that all the learners be encouraged to participate in the educational activities (Jin & Lin, 2011). Some people will be more reticent to blog or post than others and some learners may require additional encouragement. The educator can provide support and help for the students who have an urgent need of encouragement. It is important that it be established that all the learners understand how to gain technical support when necessary (Berge, 2013).

The fourth stage of Salmon's model is frequently referred to as the knowledge construction (Vrasidas, 2013). At this stage of learning the students will be prepared for an active online learning experience, and start constructing new knowledge through their interactions with each other. They often draw on the experience and skills of their colleagues (Vera, 2012). This stage includes the learners participating in discussions and actively learning

the material. They are generally more confident with regard to managing their online time and collaborations with peers. Most of the time, they will require less technical support than in previous stages (Gash, 2012).

The educator working with those learners in the fourth stage will encourage contributions by all members from the learning community (Salmon, Nie & Edirisingha, 2010). There is a need for questions for which there is no definite wrong or right answer (Wannemacker, 2011). This will lead to the learners discussing possibilities. Questions which do not have a clear solution allow for extended debates regarding possible answers. The educator must encourage the learners to reflect on the possible solutions before providing a response. The educator can help the learners by summarizing their contributions.

The fifth and final stage of Salmon's model is known as development (Vrasidas, 2013). When the learners entered this stage, they tend to be more independent of the educator and take additional responsibility for their learning and that of the group. Sometimes the learner interactions between one another will be less frequent or demanding than in the previous stages of two through four. The learners frequently are focused on individual learning as well as goals in this final stage. The learners become responsible for their learning and require little support from the educator. They will begin demonstrating critical thinking and can be more self-reflective (Salmon, Nie & Edirisingha, 2010). They will also become aware of the impact that the online space has on their learning experience.

During the fifth stage, the educator introduces activities that encourage the learners to reflect upon the learning process as well as engaging in critical thinking (Vrasidas, 2013). They should welcome feedback provided by the learners. The learner should be encouraged to take ownership of their online space. This is often done through the virtual-learning environment

providing the students with opportunities for developing their own spaces and providing choices of tools, which can be used to support learning. The educator might need to encourage learners to access previous online activities in order to enhance their understanding of the material (Salmon, Nie & Edirisingha, 2010).

**The Philosophy of Computer-Assisted Instruction**

The primary issue in 21st-century education is not the access to additional information (Gürbüz & Birgin, 2012). There is far more information available than can be easily comprehended. In fact, there is so much information that many students find it difficult to assimilate and make sense of the facts as they are presented. This is true sometimes even the most narrow of subjects. The additional information and advanced communications available means that new approaches to education are necessary (Johnson, Perry & Shamir, 2010). The goal becomes one of providing students with strategies and abilities to manage the overwhelming depth and breadth of information available online. Educators are now realizing that instead of providing students with information, the focus needs to shift to helping them learn how to more efficiently grasp new information (Mazzotti et al., 2010). This is why the focus of education has shifted to one of critical thinking which involves abilities for self-directed learning (Jin & Lin, 2011). Critical thinking can be understood as the process of a disciplined analysis, application, and conceptualization of ideas. As technology continues to advance at an increasing rate, the ability to assimilate new information on one's own becomes increasingly important. The students of today will be dealing with technologies, which do not yet exist. The best way to prepare them for this inevitability is to teach them how to learn and adapt quickly (Korucu & Gunduz, 2011).

Computer-assisted instruction is almost certain to be a dominant force for several decades

with regard to novel learning and teaching approaches (Vera, 2012) Mazzotti, Test, Wood & Richter, 2010). The myriad uses for computers with regard to education, and the ever-changing technologies ensure that it will take considerable time to fully explore the possibilities. Nevertheless, the new technology must be combined with educational principles, which are sound in order for a proper foundation to be formed for these approaches. Prior to exploring the principles and concepts involved, it is important to discuss the assumptions which have already served as part of the framework for computer-aided instruction used throughout this dissertation (Johnson, Perry & Shamir, 2010).

The basic foundation of learning and teaching being explored is that of the collaborative constructivist (Korucu & Gunduz, 2011). This involves a community of learners and teachers that interact with each other throughout the learning experience and are responsible for applying meaning to the new information. There is an inseparable relationship between social influences and personal meaning involved with educational transactions. Learning is a unified process involving socially redeeming knowledge and individual meaning, which are constantly interconnected to one another. It is vital that these two interests be considered when constructing a theoretical framework to be used for computer-aided instruction (Jin & Lin, 2011). While the technology involved is novel, the basic processes of learning remains the same.

There is a close relationship between the shared worlds and private ones of the learner when computer-aided instruction is being used (Johnson, Perry & Shamir, 2010). Many of the educational programs involving computers will have the delivery of information, which is more efficient and places an emphasis on independent learning. However, this emphasis limits the best utilization of computer-aided learning (Vera, 2012). A better use of computer-aided instruction is to place an emphasis on transactional learning. While access to information and

autonomy are not always disadvantageous, there has not been a sufficient recognition of the transactional nature of the educational experiences involving computer-aided instruction or how they can support a collaborative learning atmosphere which makes use of asynchronous learning (Owusu, Monney, Appiah & Wilmot, 2010). The computer technology and digital communications provide a unique opportunity for a community of learners to interact in ways, which are independent of place and time (Wannemacker, 2011). This means the computer-assisted approach to education, and instruction has the potential for creating an experience of education, which is ideal according to many educational theories (Salmon, Nie & Edirisingha, 2010).

The collaborative constructivist perspective that was developed by John Dewey did not include the use of dualistic thinking (Johnson, Perry & Shamir, 2010). This was especially true with regard to society and the individual. According to Dewey, the individual and society are not separate entities. Furthermore, neither society nor the individual can be subordinated by the other. Education exists as a method of teaching, which makes use of the inner play between societal values and personal interest (Jin & Lin, 2011). The interplay is characterized in the transactions which occur between the student and teacher (Korucu & Gunduz, 2011).

According to Dewey, there are at least two principles, which are important to the theoretical framework of education (Larwin & Larwin, 2011). The interaction results in ideas being generated, which serve to illuminate the external social world. In other words, meaning is shared and constructed. It is through this interaction that knowledge is confirmed and constructed, and ideas are communicated. The second principle is one of the continuity which stresses the importance of a foundation being created to accommodate future learning. This means the educational process has value for both society and the individual (Mazzotti et al.,

2010).

It is likely that if Dewey were still alive, he would support the diversity and choice involved with computer-assisted instruction (Korucu & Gunduz, 2011). This is due to involving individual variations as well as active inquiry. It is equally likely that he would strongly support the notion that reflective inquiry is important for computer-assisted education. The World Wide Web is an excellent source of information. However, for it to be educational there must be an experience of continuity of learning experiences, which are worthwhile (Owusu et al., 2010).

A definition of the educational transaction is an essential part of collaborative constructivism (Kalet et al., 2012). Constructivism and collaboration correspond to learning and teaching responsibilities within these experiences. The learning and teaching transaction is a translation in representation of the dynamics involved with the constructive and collaborative educational experience (Salmon, Nie & Edirisingha, 2010).

Knowledge represents a social artifact. Nevertheless, in an educational context, it is vital that the individual learner understands the meaning in the knowledge or improves on its understanding. It is the process of facilitating this outcome that is personally and socially worthwhile. This is at the very heart of the learning and teaching transaction. Understanding the meaning of the knowledge is common to any educational experience, including one which is computer-assisted (Kalet et al., 2012).

The educational experience has two purposes (Owusu et al., 2010). The first of these is to help the student construct meaning of their experiences based on a personal perspective. The second purpose is to confirm and refine the learner's understanding of the information. This is done collaboratively with a community of other learners. On the surface, this appears to reflect distinct perspectives of students and teachers. However, a careful consideration of the topic

indicates that the learning and teaching roles are inseparable (Wannemacker, 2011). The best understanding of this phenomenon is through conceptualizing the educational experience as a type of unified transaction. The student and teacher are merely different perspectives for the same process (Jin & Lin, 2011). These perspectives raise important questions regarding control over the process and the shared responsibility for learning. (Johnson, Perry & Shamir, 2010).

When an educational transaction occurs there are control and responsibility factors which apply to both the learner and teacher (Larwin & Larwin, 2011). The teacher's responsibilities are relatively complex and can shape and create the ever-changing learning environment. This is a challenge which can be daunting when new technologies are being used (Vera, 2012). The teacher must create social and cognitive conditions, which encourage the students to approach their learning in a way which is meaningful (Jin & Lin, 2011). This means the teacher must have considerable content expertise. Nevertheless, it is the teacher's pedagogical approach which determines how well students will assume a self-responsible stance for their learning (Wannemacker, 2011). This acceptance of responsibility by the learner is a vital step for a successful educational outcome. This is true for both the development of higher-order cognitive abilities and securing specific knowledge structures. Both items are necessary for a continuous state of learning to occur (Owusu et al., 2010).

Control is important to both learning and teaching (Mazzotti et al., 2010). The educational experience is fundamentally interactive and transactional (Selwyn, 2011). The confusion and challenges around control issues apply to the responsibility and normative role of the teacher. The teacher has responsibility for defining as well as designing the curriculum and the various educational activities. However, there is usually little opportunity for any collaboration to occur during the planning process (Wannemacker, 2011). Students are not

involved in a meaningful way with the planning of the educational process or the expected outcomes involved. This lack of student involvement is more a matter of tradition, rather than secondary to a philosophical view. This results in a situation which is contradictory. The student must accept responsibility for their learning, but they do not have input into how it is planned or carried out (Chapelle, 2010). This is a situation which is less than equal and sets the stage for the educator to motivate student engagement in the learning process.

A solution for the problem of students having little input into their educational experience is to provide them with an opportunity for dialogue with teachers regarding learning activities, expectations, and the way in which assessments are carried out (Kalet et al., 2012). Of course, there are parts of the transaction which cannot be negotiated (Selwyn, 2011). However, it is still important that students understand this is the case. If they are included in the larger learning process, and provided with choices when appropriate, the learner will have a sense of control and more readily take responsibility for educational outcomes (Gürbüz & Birgin, 2012).

The transactional perspective regarding learning and teaching is characterized by a dynamic balance between control and responsibility (Salmon, Nie & Edirisingha, 2010). Both must be congruent with the purpose for the education and the student capabilities. The congruence is determined by the educator, student, and sometimes school administration. Computer-assisted instruction emphasizes control issues and fundamental responsibility. Work remains to be done regarding an understanding about the implications that computers have on basic educational transactions (Chapelle, 2010).

**Theoretical Conceptualization**

One method for understanding the practice of education is to consider backward mapping which begins with the learning outcomes which are desired (Owusu et al., 2010). In more

advanced types of education, the outcomes are frequently associated with learning on a higher order. This type of education involves creative and critical thinking (Vera, 2012). A recent addition in many educational programs is the encouragement of self-directedness among learners. Public knowledge is becoming less permanent as the rate of technological change increases (Vrasidas, 2013). This means that there is an ever-increasing personal challenge for individuals to accommodate new knowledge and ideas (Wannemacker, 2011). This requires them to be self-directed and think critically when monitoring and managing their own learning. Discourse and critical reflection are important for ensuring the quality of learning outcomes and diagnosing any misconceptions. Critical thinking involves a holistic process of shared activities and those which are reflective (Selwyn, 2011). Discourse and critical thinking are important to computer-assisted education in order to establish a cognitive presence (Gürbüz & Birgin, 2012).

Critical thinking involves the use of a cognitive model which begins on the inside and looks outward (Gash, 2012). This is a model which reflects the phases of critical thinking between the shared and private worlds of individuals. There are multiple phases of critical thinking. These include triggering events, exploration, integration of information, and resolution. Learning, which is self-directed, focuses on issues of motivation, monitoring, and management. This type of learning is becoming an important model for understanding the multitudinous issues brought by advanced technologies. The digital age may allow for transfer of significant control of education for learning (Chappelle, 2010).

The primary role filled by self-directed learning focuses on strategies and management responsibilities (Gash, 2012). The management of learning occurs both cognitively and technically. These facets are changing education in a fundamental way. Education increasingly involves management and strategies. The technical management involves the access to an

organization of the information. Cognitive management refers to focusing on the metacognitive monitoring and cognitive tasks involved with the intellectual demands of critical thinking (Larwin & Larwin, 2011). Many traditional education approaches restrict management and development practices. Examples of restricted access include lack of a focus on self-directed learning as well as prohibitions against the use of specific technologies (Selwyn, 2011). The role of learners in education and their methods of cognition are necessarily changed. For computer-assisted learning to go beyond simply enhancing current educational practices, both the technical management and cognitive strategies must be incorporated (Veneri, 2011).

The concepts of self-directed learning and critical thinking provide a theoretical mechanism for the implementation and design of worthwhile educational practices, which are meaningful (Gash, 2012). These concepts describe processes for effective learning. To move to the next level of learning, one must address principles and approaches (Kelley, Bartholomew & Test, 2013).

One of the more promising bases of knowledge and research for gaining a better understanding of the educational experience involves exploring the conditions which facilitate relatively deep levels of understanding material (Gürbüz & Birgin, 2012). This goes beyond the simple recall of the factual information presented. When considered in a basic form, the research includes two levels of understanding or information processing. These are surface level processing and deep level processing. In the surface level processing the student must engage in road conception or reproduction of learning materials. When deep level processing is sought, the learner is expected to order and comprehend the significance in the information and integrate it into their existing knowledge base (Thomson, 2011).

The approaches to intentions and learning are influenced by the environment in which the

education occurs (Berge, 2013). Students will adapt to the characteristics within the context and expectations when they are immediately influenced by an educator. The context is strongly influenced by the learner's perceptions of the educational tasks. The perception of the student actually defines the learning context. For example, calculus maybe perceived in one way by a mechanical engineer and in a completely different way by a banker. The context also determines the strategies which are adopted as an approach to learning. The learner is going through a rational adaptation to the contextual demands placed on them in order to have a successful educational outcome. It is generally agreed that there are three domains, which influence subsequent approaches and perceptions of learning. These are curriculum, assessment, and teaching. The importance of these domains is discussed in the next three paragraphs.

Assessment has a pervasive influence which is subtle on shaping the intentions of students and the approach they use to the educational experience (Vrasidas, 2013). It is sometimes the most crucial situational influence upon the learning strategies used. The way in which a learner is assessed is usually perceived as a strong signal of what should be important for the student and how they can effectively approach their learning (Selwyn, 2011). For example, if the examination involves information recall, the students will prepare for their assessment by using memorization and will not focus on deeper levels of understanding. Since many learners are primarily concerned with passing their course, the assessment can determine the approach to learning and the information that is retained by the student (Veneri, 2011).

Curriculum is also important (Berge, 2013). The quantity of information which must be assimilated within a certain period of time is of particular importance. This is true regardless of a learner's intelligence level or inherent preferences. When the information is excessive, it will demand the student use a surface approach to their learning. There is generally a negative

impact on the deep approaches to learning when there is an inordinate amount of content to be learned, which is not under the control of the learner. For this reason, it is important to allow learners to have freedom for the choice of content when possible (Jin & Lin, 2011). Pedagogy can be crucial for resolving the information challenge. However, computer-assisted learning also creates a tool for providing an environment which is facilitative of meaningful and deep approaches to the learning situation (Kelley, Bartholomew & Test, 2013).

Domain is an important part of teaching as well (Berge, 2013). The educator will have the most influence over the learning outcomes and environment (Weller, 2011). Generally, it is the teacher who defines the assessment, content, and goals of the learning experience. The convenient access to vast amounts of information has led to their being a primary responsibility of teachers to help students find a path which is most productive in choosing the important information. The educator creates a situation of order and encourages the students to have deeper learning. This means students will engage in increased levels of higher worker processing, including self-direction and critical thinking (Thomson, 2011).

There are now excellent opportunities for the creation of engaging computer-assisted learning environments. These opportunities have increased online learning using the Internet (Rennie & Morrison, 2013). Nevertheless, the computer-assisted learning materials are usually of sequential or linear designs. These designs result in all students being forced into a single type of pedagogy. The designs contrast with the individual type of learning, which occurs when a teacher meets with a student. Computer simulation of the learning and teaching process between the teacher and student is difficult through the Internet. With the World Wide Web when a link is selected, it is equivalent to replacing a single page of information in the more traditional format. The majority of software for presentation of educational materials also

encourages a linear approach to teaching (Garrison & Vaughan, 2013).

Computer-assisted learning provides the opportunity for interactive communications and learning which nonlinear (Quinn, 2012) is. This is made possible through the use of active learning elements, which are context sensitive. These opportunities result in a situation in which various learning styles, and levels of knowledge can be accommodated. These types of computer-assisted learning environments involve the educator encoding their pedagogical approach within the design of the software and its use. This represents a more intelligent ineffective use of enhanced information technologies for the learning environment. It allows each student to be guided through the material in a type of independent study (Quinn, 2012).

While the new communication technologies and the Internet make nonlinear interactive environments for learning possible, well-designed programs have been difficult to develop and produce (Quinn, 2012). These developments and production problems are exacerbated by many educators being unfamiliar with computer programming or the tools which are required to achieve this goal. The technological components of computer-assisted learning are usually completed by technical personnel as well as instructional designers (Selwyn, 2011). Generally, these individuals do not have experience with education. This means that the perspectives of the educators for designing interactive learning, which is nonlinear have become essential. (Rennie & Morrison, 2013)

Successfully designing a learning environment which is nonlinear and interactive is not only a matter of selecting the best information technology tools (Quinn, 2012). Instead, computer-assisted learning materials must arise from the pedagogical expertise of the educator in a close interaction of a personal nature with the learner. Nevertheless, the linear design of learning continues to dominate the computer-assisted education systems (Weller, 2011). For the

computer-assisted learning to be enhanced, the information technology needs to be intelligently and effectively designed for learning. The learning materials need to be nonlinear, interactive and context sensitive, as well as able to engage learners who have various levels of knowledge (Garrison & Vaughan, 2013).

One of the fundamental goals of computer-assisted education can be to provide the student with a learning experience which is personalized and accommodates their particular learning style, knowledge base, and unique abilities (Garrison & Vaughan, 2013). In a traditional teaching situation, this personalized type of education is usually impossible. This is particularly true when a course has a high level of enrollment (Weller, 2011). The best type of education will be that which simulates a personal relationship between the educator and the learner (Dunn, 2011). The latest emerging technologies involving communications and the Internet, such as virtual worlds and wearable devices, have a potential for creating this ideal experience for education (Vera, 2012).

Non-sequential, or nonlinear, learning designs involve shifting the responsibility of mastering subjects from the educator to the learner. The instructor merely provides guidance, which allows the learner to determine their level of mastery (Weller, 2011). The learner becomes responsible for subject mastery through a self-determined rate of knowledge acquisition. This type of learner-centered pedagogy has the potential to be far more effective than the more traditional instructor centered education (Quinn, 2012).

The design of learning environments, which are nonlinear, is complex and difficult. Learners are allowed to select an entry point within the subject according to their previous knowledge. They must also be able to move to any point within the subject according to their wishes. An ideal situation involves learning being individualized for each student according to

their learning path and pace of learning. This will be determined through the choices made by the learner (Dunn, 2011). The information is broken down into packets rather than sequential steps of learning. The learner can navigate in any direction they choose through the information packets. The packets should be connected in a manner, which is coherent. This allows for ancillary information to be introduced, which is essential for the learning. This might include video, audio, images, or definitions. These should be made available from the program for direct access by the learner (Dunn, 2011). This type of design will accommodate nonlinear learning styles. It can also be used by learners who are advanced or novices. The pacing path of this learning must be set by the student and not predetermined by the educator (Rennie & Morrison, 2013).

This approach to nonlinear computer-assisted learning is analogous to selecting a page within a print textbook randomly and being allowed to move to any page within the book (Brouwer & Dekker, 2013). The interactive computer-based material for learning provides the information on the equivalent of pages, which are non-sequential and are connected in a manner, which is rational. The material allows the learner to have an educational experience which is coherent. Each of the information packets is connected to a vast array of other information packets (Garrison & Vaughan, 2013). The packets are usually in the form of hyperlinks or hypertext. Clicking on the hyperlink does not merely initiate moving forward or back to another page. Instead, it may result in additional information being supplied or a definition being given. It can also result in context pertinent video or audio being played (Dunn, 2011). The hypertext may link to an image or display as well as additional significant information, which is context relevant and provided in text form. This method results in the attention of the learner remaining focused on the subject while allowing them to have access to supplemental information

(Garrison & Vaughan, 2013).

In addition to the nonlinear design of the computer aided learning environment being interactive, it is important that visual elements be introduced in order to help the learner understand complex concepts and information (Bates & Sangra, 2013). It is of primary importance that visual elements be integrated within a context-sensitive presentation. This is particularly important in the sciences in which complex theories have real world applications. Many of the relationships which exist in these topics rely on data being displayed graphically. The computer-assisted learning allows for visual materials to be precisely positioned and displayed within context (Garrison & Vaughan, 2013).

**Computer Supported Collaborative Learning**

One of the primary requirements of education in the 21st century is preparing individuals for participation in an information society which is networked (Lin, 2011). Knowledge has become the most crucial resource for economic and social development (Dunn, 2011). One of the more promising innovations with regard to education and new technologies is computer supported collaborative learning (CSCL) (Lin, 2011). The CSCL approach has the potential for improving learning and teaching with the help of novel communication technologies. Group or collaborative learning is referring to instructional methods, which encourage students to work together on their learning tasks (Weller, 2011). This can be distinguished from the more traditional approach in which the educator directly distributes the information or skills to the learner (Quinn, 2012).

A significant amount of research has recently been done on the role that collaboration has in learning (Rennie & Morrison, 2013). This is usually done with the goal of discovering deeper theoretical frameworks for use in developing the learning environments which are created by

newer technologies. It is important to make a distinction between collaboration and cooperation as these terms are often used interchangeably in everyday language. This distinction relies on different ideas regarding the participation and role of the individual members involved in an activity language. Cooperative work is done through dividing labor among the individuals participating (Dunn, 2011). This is an activity in which everyone is responsible for helping solve the problem (Garrison & Vaughan, 2013). Collaboration involves participants being mutually engaged in a coordinated effort in order to solve some type of problem (Bates & Sangra, 2013).

The more sophisticated collaborative learning environments are designed to enhance cognitive principles (Eom, 2011). These technologically advanced systems provide advanced levels of support for the distributed process of inquiry. They also facilitate the advancing of the learning community's participant's transformation and knowledge. Learning occurs in a socially distributed process involving interactive inquiry (Weller, 2011). All components related to knowledge inquiry are involved. These include searches for information, explanations, research questions, as well as setting goals (Brouwer & Dekker, 2013). These are shared among the knowledge inquirers. A process of inquiry which is socially distributed provides support for developing the meta-cognitive skills of the participants. The imitation of appropriate cognitive processes as well as an appropriation of the advanced inquiry process may be elicited through the creation of learning environments, which mediate the stages involved in process inquiry (Dunn, 2011). This approach is superior to simply focusing on the result. This approach will allow the learner to be aware of how they advance conceptually and may serve as a method for improving their inquiry practices (Quinn, 2012).

A variety of technical applications can be applied for the facilitation of distributed and collaborative learning and teaching (Eom, 2011). These include a variety of network

applications for CSCL. It also includes various types of multimedia applications as well as experiential simulations. It is not merely the features involved with the applied technology but the way in which this technology is implemented, which can support collaboration among learners. The Internet, wide-area networks, and local-area networks provides a wide variety of tools for mediating collaboration. Examples of these tools include specialized groupware, conferencing systems, electronic bulletin boards, and email. A variety of systems have been developed for educational purposes, which enhance CSCL (Brouwer & Dekker, 2013).

Researchers have indicated that the use of computers for learning can substantially improve outcomes (Rennie & Morrison, 2013). However, the researchers make a distinction between the various pedagogical ideas of how computers can be best implemented within classrooms. This distinction makes it nearly impossible for conclusions to be reached regarding the effectiveness of CSCL with regard to its general impact. There have been a number of empirical experiments, which provide evidence that higher-order levels of social interaction can lead to better learning and deeper levels of understanding. Nevertheless, there is still a lack of evidence regarding whether the same result would be achieved in a more traditional type of classroom. Another possibility is that these types of results could be gained in classrooms using collaborative activities without computers (Brouwer & Dekker, 2013).

While several studies on CSCL have been published (Garrison & Vaughan, 2013), there have been few well-controlled experiments, which answer questions regarding the precise advantages of CSCL in traditional classroom settings or the additional value of computer networks. Many research studies have been done on the conditions in systems used as well as the conversation processes used by the students. Unfortunately, there is little information available on learning outcomes. This may be due to the variety of learning paradigms and

metaphors used within the studies (Bates & Sangra, 2013).

Technical tools and models have been developed for use with CSCL. Some of these systems are well-known and have created meaning within the development of practice and theory with regard to CSCL (Eom, 2011). For example, the Computer-supported Intentional Learning Environment (CSILE) implements a number of important factors regarding knowledge-seeking and scientific research. The CSILE may facilitate collaborative knowledge building as well as higher-order cognitive processes (Brouwer & Dekker, 2013).

Another example is the Belvidere system (Eom, 2011). This approach was based on research involving learning environments, which were computer supported. The Belvidere system prompts and focuses the cognitive activities of students through providing them with a graphical language in which they can express their data gathering and hypotheses. The learners are also able to weigh the importance of the information which is being presented (Keppell, 2012).

Another technical tool is the Learning through Collaborative Visualization Project (CoVis) (Bates & Sangra, 2013). This system involves development and research into new approaches for science education in high schools through the use of cooperative projects the students can take advantage of visualization tools, collaborative software, and advanced network technologies (Garrison & Vaughan, 2013).

While the general scientific community tends to view the ideas involved with CSCL as promising for the enhancement of learning environments, this is often not the case with practicing educators (Wankel & Blessinger, 2012). An example of this is provided by relatively large survey studies. The researchers found that many teachers in Finland did not believe collaborative learning was important for the application of computer technology in education.

This is most likely due to CSCL being a novel idea with regard to education (Weller, 2011). This finding may also indicate that the practical principles as well as theoretical ideas involving CSCL are not yet matured, and it is too early to apply them to current educational reforms. This finding reveals a need for CSCL tools and practices to be more theoretically grounded and well-developed. This will need to occur before they can be embedded within a practical educational context (Keppell, 2012).

**Multi-User Virtual Environments and Distribution of Cognitions**

During the late 1970s, the first multi-user dungeon (MUD) was developed at the University of Essex (Wankel & Blessinger, 2012). The system allowed multi-player role-playing games to be conducted over a computer network. The successful operation of the system lead to individuals and groups building virtual realities in a collaborative fashion. Despite the limited social and visual cues, the immersion in the text-based environments supported several thriving virtual communities, which demonstrated various characteristics of more traditional communities. These characteristics included friendship, betrayal, hate and love (Rennie & Morrison, 2013).

Advances in network connectivity and computational power led to the evolution of the MUDs and a higher level of human-computer interfaces, which were diverse (Keppell, 2012). Examples of these included massively-multiplayer online role-playing games (MMORPG) and multi-user virtual environments (MUVE's). The MUVEs have become well known to computer game players. Popular games include Doom and EverQuest. However, the interface is used less often for learning and teaching. Nevertheless, the interface has a number of possible uses, which are valuable for educators and learners (Brouwer & Dekker, 2013).

Education has not been completely lacking in the use of MUVEs (Keppell, 2012). The

technology has been used for the creation of online communities. These communities serve a number of purposes, including professional development and pre-service training for teachers. MUVE's also have been used for helping students experience and understand history. The experiencing of history is done through immersing them in a virtual world with the politics and emotions relevant to the historical context. The MUVE can also promote moral and social development through virtual cultures. The technology can be especially useful for providing a collaborative environment for computer programmers. MUVEs have been used to explore novel mathematical concepts and to engage in a variety of scientific inquiries (Wankel & Blessinger, 2012).

The MUVEs enable multiple participants to gain access to the virtual context (Keppell, 2012). They also can be used for interactions with digital artifacts and the representation of the individual self in the form of an avatar. The MUVE enables the participants to communicate with one another as well as take part in various experiences. These experiences frequently incorporate mentoring and modeling regarding the solving of problems which are similar to those which are experienced in a real-world context (Bates & Sangra, 2013).

In addition to the networking and technological developments required for the production of an MUVE, there are psychological frameworks, which are necessary in order to understand the impact they have on cognition (Eom, 2011). Recent advances regarding learning have been done to understand the distributed and situated nature of thought and how this applies to learning within community and workplace settings. These studies reveal cognition as being placed in both a psychological and physical context. The cognition is distributed between the individual and their tools. While situated learning and distributive cognition are generally treated as separate, the two perspectives have a relationship which is both reciprocal and complementary

(Brouwer & Dekker, 2013).

When cognitive processes are viewed from the distributed perspective, they are no longer limited to the physical presence of the individual (Keppell, 2012). In other words, thought processes are not defined as something, which has occurred within the brain of a single person. They are also not non-cognitive if they have occurred among a number of different brains. According to the science of distributed cognition, conscious activities can be distributed among multiple people, space and time, and external cognitive artifacts (Weller, 2011). When this same criterion is looked at from an educational perspective, the burdens of mental activity can be dispersed symbolically, socially, and physically between the tools and individuals. From this perspective, the advantages of MUVEs can be better understood (Wankel & Blessinger, 2012).

When the learner writes in a notebook, this object becomes both their container of learning and arena of thinking (Bates & Sangra, 2013). The essays, assignments, and notes which are in the notebook are representative of the physical distribution of memory, reasoning, and learning, which exists between the notebook and the author. The cognition is not solely within the head of the learner or the notebook. It is distributed between these two objects (Pachler & Daly, 2011).

One of the prerequisites for social distribution of cognitions is the physical distribution associated with these cognitions (Brouwer & Dekker, 2013). As an example, the use of jigsaw pedagogy relies on the students each mastering some type of knowledge through tools and experiences. The student takes advantage of a physical distribution for the cognition and works with others in applying complementary forms of knowledge and expertise (Dunn, 2011). While the collaborative experiences of learning and teaching occur among students within the world, the cognition is distributed socially (Wankel & Blessinger, 2012).

The social and physical distribution of cognitions frequently leads to the symbolic distribution of the cognitions through a variety of simple systems (Pachler & Daly, 2011). An example of these is mathematical equations. Other examples include representational diagrams and specialized vocabularies for a specific field of work (Quinn, 2012). Concept maps can transform thoughts into various tangible symbols. The notes on these maps can represent propositions and concepts. These can act as a logical bridge which exists between the concepts. Concept maps are commonly used in learning and teaching and may include assessment instruments, collaborative knowledge construction tools, and graphical organizers (Rennie & Morrison, 2013).

A barrier to the symbolic distribution of cognition within the classroom is provided by lack of language regarding this type of thought (Keppell, 2012). This means there is a need for cultivating a common vocabulary regarding distributed problem-solving, argument, explanation, and inquiry. One way to overcome this barrier is to develop a new culture, customs, and specialized language. This allows the participants to combine their distributed cognitions with symbolic meanings (Keppell, 2012).

An example of symbolic distribution for cognition which is common in MUVEs is the avatar (Brouwer & Dekker, 2013). This is the representative and virtual embodiment of the user within the environment. The avatar can be text-based or graphical. The avatar entity is defined through a number of symbols such as clothing, facial expressions, gestures, and expressions (Weller, 2011). All of these can be chosen by the participants in order to define themselves. The participation in these environments allows the user to create an online identity. This provides the opportunity for the individual to understand how people are known and recognized (Wankel & Blessinger, 2012).

The traditional classroom makes it nearly impossible for an educator to monitor the activities of each student (Keppell, 2012). The traditional classroom leaves the teacher unsure of how much the students have learned. Cold calling individual students, shows of hands, and facial expressions are methods which educators used to calibrate the learning which is taking place within their classroom (Dunn, 2011). However, these methods fail to capture all the efforts of each student. Advances in MUVEs have led to effective and efficient mechanisms for assessing how much each of the students is processing and learning (Pachler & Daly, 2011).

**Learning Management Systems**

A transformation in education is occurring with the recent renovation of Learning Management Systems (LMS) (Rennie & Morrison, 2013). These systems are designed to make use of widespread Internet access and the common use of personal computing devices. Examples of these systems include Blackboard, Moodle, Desire2Learn, and WebCt. The LMS provides additional potentials for computer-assisted learning and teaching. Examples of the types of tools provided by LMS include assignment submissions, discussion boards, videos, practice quizzes, curriculum notes, course requirements, announcements, and the providing of grades provided online by the instructor. The LMS training tools represent an additional expense during a time of reduced public funding for schools. The LMS takes effort and time to learn in order to implement the tools properly (Pachler & Daly, 2011).

Roughly, 75% of freshmen in the United States attend college with the purpose of learning more information (Eom, 2011). Students have provided feedback, which suggests that students now view learning as more important than grades. Researchers have acknowledged that student learning is a complex construct (Weller, 2011). This makes it difficult to measure accurately, and no single explanation has been agreed upon. Understanding learning involves

mastering several theoretical approaches. These approaches tend to be integrated, multidimensional, and reveal performance over a span of time (Bates & Sangra, 2013).

Students from families lower on the socioeconomic scale tend to attend community colleges; there is a higher rate of under prepared students who are enrolling in colleges in the 21st century than in previous time periods (Eom, 2011). There are educational disadvantages, which are associated with a high rate of poverty. Students from lower socioeconomic backgrounds tend to have inferior grades in the higher-education arena (Pachler & Daly, 2011).

One of the primary reasons students from lower socioeconomic backgrounds did not generally do well in college is a lack of engagement with their education (Brouwer & Dekker, 2013). The time spent on a learning task is often the determinant of positive learning outcomes. The interactions between students and teachers are frequently referred to as engagement. However, engagement not only includes personal relationships between the educator and learner, but between students and peers as well (Dunn, 2011). The students and instructors create a relationship which mediates learning. The quality of student-teacher interaction is the primary determinant of successful learning (Bates & Sangra, 2013).

Learning management systems are becoming popular as a method of increasing student engagement at the college level (Pachler & Daly, 2011). There have been well over 1000 studies on the validity of student self-reporting measures which are related to the evaluation of teaching. Student self-evaluation of learning is often an accurate and reliable method of gauging the learning outcomes. Several studies have indicated that the student reports indicated LMS to enhance their learning in a wide variety of fields. The advantage is backed up by the finding that external measures of students using LMS are associated with lower student attrition, and higher achievement test scores (Rennie & Morrison, 2013).

The use of LMS tools in an educational setting enhances student learning and communication (Wankel & Blessinger, 2012). Courses provided at Johns Hopkins, which made use of LMS had increased rates of student learning relative to conventional courses. It was discovered that education which is aided through the use of computers and the Internet can enhance as well as rich the traditional method of learning and teaching (Pachler & Daly, 2011).

The LMS serves to enhance learning by providing the sharing of knowledge, communications, and other services independent of time and space (Eom, 2011). These educational technologies offer advantages to learning for a variety of pedagogical strategies. LMS has been successfully used to improve the communication skills and problem solving of students. Students indicate that the accessibility of teachers in an LMS is substantially improved (Bates & Sangra, 2013). The development of LMS strategies benefits from focusing on the Internet skills of the learners. The majority of LMS are the Internet based. Most students are already familiar with the use of web-based technologies. They generally understand how to navigate the Internet prior to the use of an LMS. An important educational use for an LMS is data mining. Data mining involves analyzing large amounts of information in order to discover relationships or patterns. This can help students have deep insight into their learning objectives and subject matter (Eom, 2011).

Most LMS research is focused on the ease of using LMS for students and instructors. Little attention has been paid to clusters of tools or particular LMS functionalities, which are associated with superior rates of learning (Garrison & Vaughan, 2013). When an LMS is found to be successful by the majority of students, it has been determined that the engagement and environment led to students enjoying the use of the technology and their learning experience (Eom, 2011).

Regression analysis on the survey of several hundred students making use of an LMS suggests that there is a statistically significant association between the LMS tools which are used and how well the students learn their course material. Roughly 9% of student learning is associated with the specific LMS tools used (Pachler & Daly, 2011). There is a need for further research in order to isolate influences of added instructional variables such as instructor efficacy and training. Either of these factors may influence learning outcomes and the use of LMS tools (Weller, 2011). Educators may have various pedagogical skills with regard to the use of LMS tools, which could augment or undermine the learning experience for the students. Additional research is required in order to establish relevant theories and promote the necessary educational reforms (Wankel & Blessinger, 2012).

**Traditional Method Instruction: Strengths and Limitations**

Traditional methods of instruction are considered time-consuming and ineffective. (Deaney, R., *et al;* 2003). There are many shortcomings of traditional instruction and teaching that have been documented in previous literature. Traditional instruction can have minimal to no benefits to students in high school. (Olga Pilli., & Meral Aksu. 2013). The case remains the same for students learning physical science. The major advantages of traditional teaching methods have been listed in this paper. Traditional methods enable the educator to expose students to unpublished data. The method also enables instructors to expose students to learning materials that are not available in the market. Traditional methods also have student-centered environments. The educator can precisely discuss the content unlike studying in CAI methods. The educator has full power to discuss the content and answer unanticipated questions and doubts by students. Educators have full access over the content and have the capability to encourage the students in the subject. Traditional classroom teaching involves a large number of

students with varying academic capabilities. Traditional methods of instruction would help target students to grasp and understand the subject matter. Instructors in traditional methods of teaching can complement and clarify the text material present in the content. In some cases, students depend on the teacher-centered methods to understand the concepts of the subject. Not all students benefit from traditional teaching methods (Olga Pilli., & Meral Aksu. 2013). Traditional classroom teaching would enable instructors to interact with students in a non-verbal manner. Traditional teaching would also enable students to participate and clear their doubts effectively. Many students prefer student-centered and traditional methods of instructions. Lastly, traditional teaching methods facilitate large-class communication (Deaney, R., et al; 2003). On the other hand, traditional methods of instruction has many limitations. The method places students in a passive role compared to an active role in a computer-assisted method. The passive role of students in traditional methods decrease their learning abilities. Researchers have proved that cognitive skills of students was low compared to students placed in a computer-assisted environments (Eom, W., & Reiser, R. 2000). Traditional methods of teaching are teacher-oriented. In contrast, (Eom, W., & Reiser, R. 2000) suggests that a combination of traditional and computer-assisted teaching improves the cognitive function of students. The major drawback of traditional methods of teaching is that educators need to understand the needs of each student (Eom, W., & Reiser, R. 2000).

Traditional methods are based on one-way communication. Instructors would have to pay attention and understand the needs of the student concerning non-verbal feedback. Students with poor memory retention may suffer the most from traditional methods of teaching. Moreover, traditional methods of instruction would require students to revise and read subject material after class. Most homework is unguided and away from the teacher. Academic performance of

students from traditional classroom teaching is said to be lower compared to students from modern classroom teaching methods (Felder, R. M. & Brent, R. 1996). Instructors are not able to influence students through traditional teaching methods (Felder, R. M. & Brent, R. 1996). Low self-esteem, poor confidence levels, and low-memory retention are some of the common issues observed in students from traditional classroom (Flake, J. 1994 & Gabrielle). The learning abilities of students are low in traditional classroom teaching. Stress among instructors of traditional classroom teaching is a common issue. Lastly, traditional methods facilitate large-class communication with poor academic outcomes (Flake, J. 1994 & Gabrielle, D. M. 2003).

**Computer assisted instruction as a supplemental strategy**

(Daniel, J., H. 2010) reviewed the effects of computer-assisted instruction strategies on science achievement of students in Japan and United States. Computer-assisted teaching has revolutionized the learning experience in high school settings. (Gehring, J. 2003) suggests that implementation computer-assisted strategy in the high setting would improve the academic performance of students to a significant extent. Simulations and virtual labs provide a platform that encourages students to actively participate in the lecture. The use of animations and videos making learning interactive and realistic (Gehring, J. 2003).

Educators benefit from computer-assisted instruction benefits since most of the subject matter is described in a realistic manner (House, J. D. 2003). Simulations and virtual lab settings encourage students interact and communicate with the instructor in an efficient manner. Virtual labs provide simulations that motivate the students to learn and grasp the subject efficiently. (Hancock, D. R. et al; 1995). Stimulations allow students to learn the subject matter in an interactive manner. Computer-assisted teaching methods focus on large-number classrooms with

a goal to target students with different learning abilities (House, J. D. 2003). Interactive voice support, animations, graphical representations, and videos help students with different learning capabilities. For example, students who do not understand concepts from textbooks would be able to benefit from animations and videos. Computer-assisted software would also record the progress of each student display the results based on the child's performance based on different activities. Since the entire process of teaching and learning in computer-assisted methods is interactive, realistic, fun, and simple, many students are motivated to participate in the learning process (Hancock, D. R. et al; 1995 & House, J. D. 2003).

**The advantages of computer-assisted instruction:**

(Keller, J. M. 1979) states that Computer-assisted instruction (CAI) is a novel technique that provides enrichment of a course through added variety. (Hancock, D. R. et al; 1995) demonstrated that computers would wait patiently for the right answer without expressing annoyance or anger with a wrong response from the student. On the other hand, educators may express anger or annoyance in traditional teaching methods that might affect the student's academic performance. (Keller, J. M. 1979) stated that large amount of data can be handled in computer-assisted instruction without drudgery.

Traditional methods of instruction involve passive participation of students during class. However, with the help of simulations and virtual labs, it has become possible for students to actively participate during the lecture (Lashaway-Bokina, N. 2000). Active participation is associated with quick learning and high memory retention in students. Computer-assisted instruction enables students to process real-life scenario and increases their critical thinking skills. Students become inquisitive about the subject matter (Keller, J. M. 1979).

One of the major advantages of computer-assisted learning is the ability of students to provide immediate feedback. Simulations and virtual labs provide a platform that encourages students to actively participate in the lecture. The use of animations and videos making learning interactive and realistic. Students can pause and provide immediate feedback during virtual teaching. Academic achievement is associated with immediate feedback from students during the lecture (Gibbons, A. S., *et al;* 1997). Immediate feedback by students would ensure fast learning, thinking, and memory retention capabilities (Gibbons, A. S., et al; 1997).

Computer-assisted instruction helps the instructor to understand the subject matter in an effective manner. Educators who teach using computer-assisted methods are less stressful and infinitely patient. (Granland R., et al; 2000). Educators benefit from computer-assisted instruction benefits since most of the subject matter is described in a realistic manner. (Granland R., *et al;* 2000). Simulations and virtual lab settings encourage students interact and communicate with the instructor in an efficient manner. (Demirel, O. 2004) observed low stress-levels and high tolerance levels among educators. Educators reflect on the virtual lab models and encourage students to participate in the stimulations provided. In traditional methods, educators taught students on blackboard with great efforts. However, the learning output from students was considerably low (Granland R., et al; 2000). Educators often lost their patience during the teaching process but the same was not observed in computer-assisted instructional methods (Demirel, O. 2004). The development and improvement of computer-assisted instructional teaching methods have increased the performance of educators. (Granland R., et al; 2000).

**Motivated learners:**

Computer-assisted instruction methods are known for their interactive and realistic working environments. Virtual labs provide simulations that motivate the students to learn and grasp the subject efficiently. Stimulations allow students to learn the subject matter in an interactive manner. (Forinash, K. & Wisman, R. 2001) suggest that students who learn from virtual labs and stimulations are motivated to learn science. Educators in computer-assisted teaching methods play a minimal role and allow students to participate in the learning process. Since physical science cover many topics on nature, stimulations would allow students to perform laboratory associated tasks without visiting one. Since the entire process of teaching and learning in computer-assisted methods is interactive, realistic, fun, and simple, many students are motivated to participate in the learning process (Forinash, K. & Wisman, R. 2000).

**Provides consistency in presentation**

Computer-assisted methods have word processing and presentation software that enable teachers to provide precise and accurate learning tools. Computer-associated software would enable the instructor to present the learning module in an interactive and precise manner. The instructor has full control over the learning module. The instructor can make necessary changes in the learning module as per the needs of the student. Since the presentation contains subject matter for students with different learning abilities, computer-assisted instructional methods are considered to be the best in class for teachers (Jackson, D. E. 1997). The software used in computer-assisted teaching methods enable the teacher to make a presentation as and when required. (Min, R. 2001). Presentations made by the educator would ensure interactive learning and effective communication between the student and the teacher. Consistency in the presentation is observed in computer-assisted teaching methods. Since the data is saved in a

database, there is no need for educator to make a new presentation. The ability to make changes in the presentation is another advantage (Min, R.2001).

Computer-assisted teaching methods focus on large-number classrooms with a goal to target students with different learning abilities. Simulations would provide different levels of learning tools for different students. The system would ensure that all students learn the given module the same day. (Ross J. R. 1994; Halal, W., & Liebowitz, J. 1994). Virtual labs are based on realistic environments. Most of the virtual labs consist of different levels of simulations and modules. Students would select the level of learning based on their learning capability. Computer-assisted software would also record the progress of each student display the results based on the child overall performance. (Halal, W., & Liebowitz, J. 1994).

**Able to branch to provide appropriate content presentation to the learner:**

Many students who learn physical science may not understand the allied branches of the subject. It is important for the instructor to introduce different learning modules to provide appropriate content to the student. Traditional methods of instruction may not have the flexibility to provide appropriate content to all learners. In such cases, computer simulations would assist students (learners) to study allied branches of physical science. Animations and graphical representations would allow students to learn the subject matter in depth. Labelled diagrams would assist learners on new aspects of physical science. Question answer sessions and access to educational databases would enable students to become proficient in an allied branch of the subject. (Drenoyianni, H. 1998)

**Can present concepts or processes dynamically**

As mentioned earlier, computer-assisted methods of teaching make optimum use of the computer. Virtual labs would assist students in learning and visualizing real-life experiments and data that would not be possible through traditional classroom teaching. Interactive voice support would help students in daily task present in the learning module. (Halal, W., & Liebowitz, J. 1994). Computer-assisted teaching methods include a wide variety of representation like videos, graphs, animations, virtual robots, labelled diagrams and simulations. (Kim S., & Lee W. 2000)

**Teacher's drawbacks can be remedied:**

Traditional methods of teaching cannot rectify the mistakes made by the teaching professional. Computers would assist teachers in vocabulary, grammar, and collecting factual data. In some instances, computers would identify mistakes made by teachers before, during, or after the course. Virtual robots would play an important role in rectifying mistakes made by teaching professionals. Virtual robots would assist teaching professionals in finding factual data as per the subject requirements. (Ross J. R. 1994).

**Limitations of Computer-based instruction:**

CAI methods are known to have revolutionized the learning experience in students. Interactive learning and the realistic settings of computer technology are some of the strengths of computer-assisted instruction methods. (Panagiotakopoulos, C., & Ioannidis, G. 2002) demonstrated the limitations of computer-assisted instruction methods. Some of the limitations of CAI methods have been enlisted here below:

**Equipment and software can be costly:**

The software used in computers to assist teachers and students through virtual labs and simulations come with a heavy price tag. Some of the software are costly and not many schools and institutes are ready to pay for such software. Moreover, software up gradation and maintenance are also costly. Schools and institutes in developing countries would find computer-assisted technology unfeasible because of the lack of financial funding. The equipment used in computer-assisted training are costly. Maintenance of equipment is associated with high cost, and timely upgrades. Countries like India, Bangladesh, and Pakistan may not have the resources or financial support to equip their schools with such technology. (Panagiotakopoulos, C., & Ioannidis, G. 2002)

**Development takes time and money:**

The installation process of equipment and software of computer-assisted technology is often time-consuming. Most of the equipment would need separate storage and maintenance rooms. Since many schools and colleges already have a space-constraints, it would be difficult to implement computer-assisted instruction methods. The implementation of the strategy would take several weeks to months. The technical process of installing and developing the software is also time-consuming. The development of CIA is associated with infrastructure development. The process of development of computer-assisted technology is time consuming and associated with a high cost (Park, I., & Hannafin, M. 1993).

**Not all learning outcomes are well addressed by CAI:**

As mentioned earlier, computer-assisted instruction (CAI) is known for its superior learning experience that helps teachers and students in different school settings. (Vernadakis, N.

1999) demonstrated that not all learning outcomes were addressed in CAI-associated studies. The learning outcomes of a teacher-centered CAI and student-centered CAI were not well-defined. (Siddiqui, U & Khatoon, T. 2013) demonstrated that students in teacher centered CAI methods had better academic achievement compared to students who were placed in student-centered CAI groups. Many students would not benefit from computer-assisted technology alone. Some students would seek traditional student-centered methods of instruction to clear their doubts. Theorists suggest that CAI methods would hamper the interpersonal and communication skills of students (Vernadakis, N. 1999). To conclude, not all learning outcomes are well addressed when implementing CAI.

**Unsophisticated applications may not make good use of the computer:**

Computer-assisted instruction was newly introduced in the education industry. (Salovaara, H., et al; 2001) stated that many applications associated with the software and equipment do not make good use of the computer. (Salovaara, H., et al; 2001) also stated that applications do not meet up the standards of programming and simulations used in advanced CAI methods (Salovaara, H., *et al;* 2001).

Many computers have advanced operating systems like Windows 8 or 8.1, Mac OS X, and Linux. On the other hand, the applications associated with CAI were developed to run on old versions of computer operating system. (Sanacore, J.1997; Scheidet, R. 2003) stated that overall output (Visualizations) are not up to the mark due to programming errors between the applications and the operating system. Many applications do not make use of the advanced features of the computer (Sanacore, J.1997; Scheidet, R. 2003).

**Simple CBI has limited modalities (but multimedia is changing that):**

Computer-based instruction (CBI) is similar to computer-assisted instruction (CAI), the latter involving both the teacher and computer for instructional purposes. Computer-based instruction may not necessarily have all the features of realistic learning. Some of the software used in CBI have limited modalities. The number of teaching modules, virtual reality-based animations and graphics are limited in most CBI methods. Physical science students depend on teachers to understand the concept of the allied subjects. Traditional methods of teaching are not capable of providing a realistic environment. CBI methods enable the teachers to instruct concepts in an interactive and visualized manner. However, not many functions of CBI methods provide interactive learning. There are a few technical glitches present in most of the CAI software. With the advancements of multimedia, CAI methods include animations, videos, and graphical presentations for physical science students. For example, volcanic eruptions are presented using advanced 3-Dimensional graphics. However, for all modalities to work efficiently, the operating system of the computer and the software version should be similar (Sarapuu, T., & Adojaan, K. 1999).

**Teacher's competence in using technology:**

The implementation of CAI in high school settings is considered as the best educational innovation in modern times. However, the development and implementation of CAI methods need a lot of comprehensive training. Many teachers lack in computer knowledge. Theorists suggest that being computer literate would not be sufficient for the successful implementation of CAI methods in high school. Teachers would need to understand the concepts of operating system, programming, software, hardware, virtual labs, and simulations. Many developing countries like India may not have teachers who are well-versed with computer technology. The

training of teachers in these competent areas is necessary for the success of computer-assisted instruction (Shapiro, W. L. 1999 & Shia, R. M. 1998).

**Virtual Lab Simulations in High School Setting for physical science students**

Teaching physical science students is a challenge to most teaching professionals. Traditional methods of instruction would only give a summary of the subject matter. The major drawbacks of traditional learning are the lack of a realistic environments and interactive learning. However, with the advancements in technology, teaching physical science students has become easy and simple. Educational technologies have made differences in key areas for physical science students (Silver, H. F., *et al;* 2000; Song, S. H., & Keller, J. M. 1999; & Tapscott, D. 1999).

**Virtual experiments and activities:**

Virtual experiments enable students to learn and perform experiments without physical difficulties. The cost and time associated with physical performance of an experiment are reduced to a significant extent with the help of virtual experiments and activities. Virtual activities enable students to visualize a scientific representation and manipulate experiments using virtual tools (Tavani, C., & Losh, S. 2003).

**Simulations of the natural world:**

Physical science students benefit the most from simulations. Simulations are designed for students to work independently or in groups. Simulations help students understand the real world via graphical representations. Students learn to make observations, test hypothesis, collect data, and communicate with each other using advance simulation tools over the computer (Theroux, P. 1994; Thornburg, D. 1995; & Tobin, M. 1999).

**Virtual instrumentation/data collection:**

CAI methods have helped students use virtual instruments to perform experiments in real-time. The use of virtual equipment (that are costly and difficult to handle) in reality are one of the major advantages of CAI methods. Students perform difficult experiments virtually over the computer. Data collection and storage is possible through advance educational databases and websites (Viadero, D. 1999 & Johnson, A., K. 2000).

**Virtual simulations used in the physics classroom**

(Cunha E., A, et al 2014) demonstrated the efficiency of computer simulations in a physical science classroom. Computer simulations in the physical science classroom helped students engage in the subject matter. (Cunha E., A, et al 2014) demonstrated that how the teacher's mediation actions helped the student's productive engagement using computer simulations. Students using computer simulations have better understanding of physical science subjects like physics and chemistry than students engaged in traditional coaching (Cunha E., A, et al; 2014).

Physics is considered as one of the most fundamental natural sciences that includes relationship among a wide variety of ideas and study of universal laws and behaviors. Experiments help young scientists to understand different ideas and theories in physics. However, traditional laboratory experiments have a number of limitations. (Bajpai M, 2013). A scientific study demonstrated the effectiveness of virtual labs in a physics classroom. (Bajpai M, 2013) developed concepts of physics with the help of virtual labs. Virtual labs are known to play a significant role in engaging students to understand underlying concepts and theories of physics. (Bajpai M, 2013). (Bajpai M, 2013) stated that development of physical science concepts

through traditional methods is likely impossible. Traditional methods have a number of limitations. Virtual lab simulations are considered to be one of most powerful methods of teaching and experimentation in labs. (Bajpai M, 2013). (Bajpai M, 2013) evaluated the effectiveness on the learning skills of physics students with computer simulations. It was observed that students learned the objectives concerning the photoelectric effect in a better way compared to traditional or real lab experimentation. Virtual labs should be recommended for teaching the concepts of physics in high school settings (Bajpai M, 2013).

There is a high demand of virtual labs and simulations for physics education in developed and developing nations (Singh, J et al 2009). Traditional methods of teaching and laboratory experimentation is considered to be time-consuming and ineffective for students. (Singh, J et al 2009). (Singh, J et al 2009) demonstrated the need for open source virtual labs for school physics education. However, the study was primarily involved in the creation of virtual tools to help students understand different concepts of physics. The creation of open virtual tools would involve a series of computer programs and algorithm analysis. The developments of open source virtual labs would enable large number of students to access and learn different concepts of physics. It is important that all students receive high quality education and by the development of open source virtual labs, imparting high quality education would be easy (Singh, J et al 2009).

A similar study was published in the Australian Journal of Educational Technology. (Wegener M et al; 2012) demonstrated that development of a physics teaching package helped students understand difficult concepts of physics. The study involved the development of a virtual physics teaching package that was based on a reality game-like software. However, the teaching package involved a series of cycles that evaluated the effectiveness of the virtual

teaching package. The cycles involved instructional and development software. The overall teaching package included an instruction manual, laboratory manual, and real-time simulation software. Virtual teaching packages are known to enhance the learning experience among physics students. However, the development of the teaching package was costly and time consuming (Wegener M *et al;* 2012). Conventional teaching methods offer minimal or no benefit to students with a weak mathematical background. Modern methods of teaching like virtual labs and simulations would help such students in understanding the subject matter in an efficient and easy manner (Wegener M *et al;* 2012).

**Virtual laboratories used in the chemistry classroom**

There is a demand for alternative methods of teaching in the chemistry classroom. Many researchers suggest the use of computers in the chemistry classroom (Tatli Z, & Ayas A. 2011). Many laboratory applications can be conducted with the help of virtual labs. There has been a significant change in the advancement of educational technology. Most of the chemistry laboratory experiments involve long hours of experimentation. In some cases, students are exposed to harmful chemicals that increase the chances of accidents. Virtual laboratory has become a necessity for most chemistry classrooms. (Tatli Z, & Ayas A. 2011). A scientific study demonstrated the scientific achievement in the implementation of virtual labs in the chemistry classroom. The main objective of the study was to evaluate the gaps in imparting high quality education to chemistry students. Virtual chemistry laboratory (VLC) was implemented in ninth-grade chemistry classrooms. However, statistical analysis using SPSS software revealed no benefit of VLC in scientific achievement and the ability to recognize laboratory equipment. Thus, students do not benefit from virtual chemistry laboratories. (Tatli Z, & Ayas A. 2011).

The effects of virtual laboratory are known to have minimal or no benefit to students in many scientific studies (Winkelmann, K *et al;* 2014). A similar study was conducted to demonstrate the effects of conducting chemistry experiments within the virtual world of second life. Virtual laboratory experiments had no major effects on students based on academic achievement and laboratory performance. Students in virtual laboratory experimentations could recognize laboratory equipment similar to what students recognized in real-life experimentations. The current status of virtual labs for chemistry students is not strong. There is a need for improvement in the virtual simulations and labs used in the teaching modules. (Winkelmann, K *et al;* 2014).

Virtual laboratories have been implemented in high school settings to evaluate the learning outcomes of students in organic chemistry. (Climent-Bellido, MS, *et al;* 2003). Organic chemistry involves the study of reactions, structures, properties of various organic compounds. Conventional methods of teaching are unable to provide students with 3-dimensional structures of organic compounds. Students can learn 3-dimendional structures of organic compounds with the help of virtual laboratories. Organic chemistry experiments are considered to be physically challenging to students. Virtual laboratories would provide students with virtual tools that mimic organic experiments. (Climent-Bellido, MS, *et al;* 2003). Students familiar with virtual laboratories perform better than students who are not familiar with virtual chemistry laboratories (Climent-Bellido, MS, *et al;* 2003). Virtual chemistry laboratories help students understand various concepts of organic chemistry like reactions and properties of organic compounds in an efficient manner (Climent-Bellido, MS, *et al;* 2003). Virtual chemistry labs are associated with higher academic performance in students than students who are not familiar with virtual learning experiments. (Climent-Bellido, MS, *et al;* 2003).

Virtual laboratory applications have played an important role in chemistry education. With the advancements in mobile technology, scientists have developed mobile and computer-based virtual laboratory applications for students and teachers. (Tatli, Z & Ayas, A, 2010). Virtual laboratory applications have helped students grasp and understand tough organic experiments and concepts. Virtual lab application s have proven to improve the academic performance of high school chemistry students. (Tatli, Z & Ayas, A, 2010). However, there are many technical glitches in many of the virtual lab applications. There is a need of improvement in the field of virtual lab applications. (Tatli, Z & Ayas, A, 2010).

**Virtual laboratories and simulations used for astronomy students**

Virtual laboratories and simulations have played an important role in allied branches of physical science. Hands-on training through virtual labs and simulations are common in many educational institutes and universities. Astronomy consists of observational experiments and studies compared to other physical science subjects that include experimental studies. There is an increasing demand for virtual simulations to educate students enrolled in astronomical studies (Marschall, A. 2000). Many universities and institutes find it difficult to implement or develop expensive equipment for students conduct observational experiments. However, with the advancements in technology, it is possible to develop virtual simulations for students enrolled in astronomy. (Marschall, A. 2000) claims that in recent years astronomy has gone digital due to the advancement in fast personal computers. Computers and online databases have made the experience of astrophysics realistic. The use of stimulation software enable researchers to study the universe over their desktops (Marschall, A. 2000). The use of computers in astronomy dates back to 1992 where virtual learning was initiated by project CLEA (Contemporary Laboratory Experiences in Astronomy). Researchers have developed computer-based exercises that

stimulate important aspects of astronomy research. The CLEA software consist of 9 exercises till date. Each exercise contains technical guides for teachers and students, software, and technical guides for students. (Marschall, A. 2000). The CLEA project has different software settings for primary and secondary astronomy classes. The CLEA software is most widely used astrophysics software in the United Sates. The CLEA project is considered to be the most successful virtual astronomy exercise with its presence in over 60 countries worldwide. Lastly, CLEA exercises are associated with improved academic understanding of astronomy by middle-school and upper-class astronomy students. (Marschall, A. 2000).

**NASA Connect Program**

The National Aeronautics and Space Administration (NASA) is involved in the research of aerospace and aeronautics. NASA is involved in exploring new orbits in the universe by using high-end space crafts. However, NASA have their own educational department that is associated with implementing educational programs in different school settings. NASA aims in imparting high quality education to students in the United States and rest of the world. Many of the educational programs initiated by NASA were based on virtual learning and advanced simulations. NASA's education office communicates with teachers and professors of different universities and institutes around the world to educate students in allied field of aerospace and aeronautics research. NASA aims to bring the next generation closer to aerospace research. NASA's connect program enable students from different levels to explore the solar system through a virtual learning module. NASA has their own simulation theatre where students learn the about the universe in a realistic environment (NASA education, 2014).

NASA is known for high quality training for teachers and the world's best virtual training academy for future astronomist (Byers A, *et al;* 2014). NASA is also known to invest in advanced and beginner programs for all ages to inspire and engage people from all age groups to learn and explore the universe. The agency is also involved in providing training for teachers to teach students in the field of science and technology. The NASA connect program is involved in providing the best virtual learning experience for high school students (Byers A, *et al;* 2014). The NASA connect program has revolutionized the learning experience for students and explorers involved in astronomy research. To conclude, there has been substantial advancements in the field of astronomy and virtual learning (Byers A, *et al;* 2014).

**The advancements of Virtual labs and simulations**

(El-Sabagh, E., A., H. 2011) compared the impact of traditional educational experience and web-based virtual lab environment in relation to the science process and conceptual understanding skills in fourth grade natural science students. (El-Sabagh, E., A., and H. 2011) found that learning outcomes was higher in students placed in the virtual-lab environment than students placed in the traditional teaching group. (TÜYSÜZ, C. 2010) demonstrated the effect of virtual laboratory on student's achievement and attitude in chemistry class. The author highlights the importance of virtual laboratory for chemistry students. (Anderson, R., B. 2010) created a virtual lab environment for students called Xen world. Xen world is known for its low-cost option for education by using open source software and minimal hardware. (Anderson, R., B. 2010) demonstrated that virtual lab environment (Xen world) has a significant impact on students in terms of learning outcomes and academic performance.

(Riberg A, 2009) designed web-based applications for physics students to assess learning outcomes. (Riberg A, 2009) designed ten web-based applications for physics students. Out of the ten applications, three applications showed positive impacts on students. For example, students found the web-based applications made learning fun. (Scott, A. 2009) demonstrated the efficiency of online science courses in a rural community college. (Scott, A. 2009) also found that the number of student enrollments have increased in the Mississippi Virtual Community College due to the advancements in web-based instruction. (Coombs, John, M., 2007) demonstrated enhanced learning in students through the development of virtual laboratory. Virtual laboratory enhances the learning experience in masonry construction and masonry testing in students (Coombs, John, M., 2007).

**Summary**

**Science achievement with regards to ethnicity in the high school setting**

| STUDY | PURPOSE | PARTICIPANTS | DESIGN/ ANALYSIS | OUTCOMES |
|---|---|---|---|---|
| Nwokolo, C *et al;* (2012) | Evaluate the efficiency of CAI in African Students | Not Mentioned (N/A) | Quasi Experiment/ ANOVA | Improved academic performance in math (African Students only) |

| STUDY | PURPOSE | PARTICIPANTS | DESIGN/ ANALYSIS | OUTCOMES |
|---|---|---|---|---|
| Okojie CM *et al;* (2006) | Evaluate the efficiency of CAI in African-American students. | (N/A) | Case-Control Quasi Pre/Post-test analysis | Improved scientific achievement in both groups. |
| Morton, AD et al; (2007) | Evaluate CAI in pre-medical African students | N/A | Quasi experiment Pre/Post-test Analysis. | Increased critical thinking and understanding of medical concepts in African (Black) students. |
| Owens, E.W. & Waxman, H.C. (1994) | Efficiency of CAI in African-American-students | N/A | Comparative Design Pre/Post-test | Improved scientific achievement in African-American students. |

| STUDY | PURPOSE | PARTICIPANTS | DESIGN/ ANALYSIS | OUTCOMES |
|---|---|---|---|---|
| Yook, LA. (2012) | Evaluate the difference in Academic and professional performance between Korean-Americans and African-Americans using CAI. | N/A | Comparative design | Improved Academic and Professional performance in both ethnic groups. |
| Siddiqui, U & Khatoon, T. (2013) | Evaluate the efficiency of CAI in Asians (Indians) | N/A | Quasi & Case control | Improved academic performance, critical thinking and cognitive function in Asian (Indian) students. |

**Science achievement with regards to academic performance in high school setting**

| | | | | |
|---|---|---|---|---|
| TÜYSÜZ, C. (2010) | Effect of Virtual labs on the academic performance of chemistry students. | N/A | Quasi Observational | Improved academic performance in chemistry class. |
| (Johnson, A., K. 2000) | The importance of computers in classroom teaching and its association with improved academic achievement in students | N/A | Observational | Improved scientific achievement in students. |
| K. A. Owusu *et al;* (2010). | Evaluate the effects of CAI on senior biology students. | N/A | Quasi ANOVA | Improved cognitive and academic performance in students. |
| Yoder, Z. & Elias J. (1998) | Computer-assisted techniques may also play an important role in the improvement of general education development (GED). | N/A | Quasi Observational Case-Control ANOVCA | Improved critical thinking of students enrolled in physical science. |

| | | | | |
|---|---|---|---|---|
| TÜYSÜZ, C. (2010) | Effect of Virtual labs on the academic performance of chemistry students. | N/A | Quasi Observational | Improved academic performance in chemistry class. |
| Basturk, R. (2005) | To evaluate the improvement in statistical reasoning in students after CIA teaching methods. | N/A | Quasi ANOVA | CIA techniques improved the statistical reasoning of students to a significant extent. |

**Science achievement with regards to gender in the high school setting**

| STUDY | PURPOSE | PARTICIPANTS | DESIGN/ ANALYSIS | OUTCOMES |
|---|---|---|---|---|
| Yusuf, OM et al; (2010) | To evaluate the academic performance between male and female students after CAI. | 120 | Quasi-experimental involving a 3 x 2 factorial design. Analysis of Covariance (ANCOVA) | CAI helped students achieve high academic grades but there was no significant difference between male and female students. |

| STUDY | PURPOSE | PARTICIPANTS | DESIGN/ ANALYSIS | OUTCOMES |
|---|---|---|---|---|
| Bakac, M et al; (2011). | Evaluated the efficiency of computer-assisted instruction on male and female students. | 28 | Case-control Observational | There was no significant difference between academic performance in male and female students studying physics in high school settings. |
| Tienken h. & Maher J (2008) | Evaluated the efficiency of computer-assisted instruction on male and female mathematics students | 121 | Case-control Observational | The researchers observed significant improvement in geometry and algebra solving skills in males |

Many researchers have documented the key aspects of traditional methods of instruction and their impacts on the overall performance of students. In the past ten years, researchers have highlighted the importance of computer-assisted instruction as a supplemental strategy to teach science in high school settings. However, researchers have captured the interest of real-life experiences in the form of virtual lab simulations or computer-assisted instructions for students in high school settings. (Demirel, O. 2004). Primary to the following literature review in this controlled exploration identifies and reports comparative outcomes of computer-based instructional (CBI) strategies in teaching application used in lieu of traditional classroom teaching methodologies for instructing physical science to suburban high school students.

Twenty-first century education typically uses supplemental virtual instruction (SVI) and computer assisted instruction (CAI). As money is raised to bring technology into the classroom, data must be gathered to assess the effectiveness of improving student achievement. Blended learning which encompasses the student controlling part of their learning environment, is using the computer to extend the classroom beyond the walls of the school. This work highlights the importance of computer-assisted instruction delivered by virtual labs and simulations on physical science students in high school settings. This work also compares the effect of the virtual world with respect to gender and ethnicity

Consequently, the focus of the two research questions first investigates what among literature presented in this scholastic endeavor reveals to what extent gender difference in achievement on benchmark testing with learners receiving SVI exists. In doing so, the prevalence of prevailing data reveals more published studies on the importance of gender "attitude" toward CBI learning rather than target test outcomes based on gender difference among physical science students. Conversely, the second inquiry of this research has a better showing of published conclusions determining significant differences in achievement on benchmark testing of students receiving SVI focusing on racial demographics including African American, Caucasian, and Hispanic. Together, while this proves a better showing than the gender-based data nonetheless this area remains lacking in any abundance of published study outcomes of any solid research.

School science instruction using technology continues growing over the last two decades (Johnson, 2000). According to Chia-Yu Wang, Hsin-Kai Wu, Wen-Yu Lee, Fu-Kwun Hwang, Hsin-Yi Chang, Ying-Tien Wu, and Chin-Chung Tsai (2014), from 1990 to 2011 the studies on this subject number 42 published articles. The findings of the Wu et al. (2014) meta-analysis

concludes among the process that instructional directions remain a valid consideration when using technology for teaching (p. 307) as is further discussed in the scholastic literature review.

The literature research for this study finding remains sparse as directly linked to high school physical science students learning provided from data using CAI strategies. This same condition is true in connection to locating outcomes of gender-related assessments of benchmark testing. Additionally, locating results of such targeted research samplings are problematic from an inquiry perspective. Nonetheless alternative and relevant scholastic options do exist substantiating the rationale of this aspect of this dissertation. This investigative literary review goal states the purpose of the review is to identify significant gender differences in testing results of physical science SVIs. However, the results show a measurable lack of study outcomes for high school students.

Still, the scholastic effort proves advantageous with ascertaining literature from studies among first year college students and thus, keeps the discourse just as pertinent. Identifying this particular group provides a logical link between older adolescents and young adult learners representing similar aspects as part of the third stages of adolescent development connecting high school and first year higher education students within the same cognitive grouping (Steinberg 2001).

**Achievement using Supplemental Virtual Instruction versus Standard Instruction**

Primary to identifying the relationship of gender assessments of benchmark testing outcomes among suburban high school students learning physical science using SVIs first discusses literature reporting on the general achievement comparison of high school science learners with the control sampling of participants not engaging in SVI science instruction.

Accordingly, this establishes the parameter for further investigation of testing results according to gender and science SVI learning.

While ideally, the existence of a plethora of literature providing hard evidence of the specific focus of the two hypothesis questions framing this portion of this scholastic enterprise exists, the fact remains that it does not. Literature substantiating the specific quest directed by the two questions posed in the introduction of this discourse however does exist through different avenues that pragmatically apply to the investigation of this literature review as indicated throughout the ensuing pages from a different perspective as this discourse reveals.

The question of the impact of scientific virtual labs (VL) for secondary level science instruction poses its own inquiry according to Tatli and Ayas (2010). The researchers advise how, "On the other hand, studies are not sufficient to display the impact of VLs in pedagogical dimension so new studies should be done to investigate this dimension." This underscores not only the lack of academic investigation on the use of VL effectiveness for older adolescent physical science student learning goals outcomes according to data measuring benchmark testing outcomes, but additionally, the lack of literature for gender related comparisons of benchmark test outcomes compounds the need for adjusting this literary research (p. 941).

Connected to this reality Henderson et al. (2000) argue the validity of further research (cited by Poland et al., 2003, p. 229) nonetheless, shows a number of published research outcomes does exist on how teaching incorporates CBI technology use built into organized curriculum in different areas of learning programs. These studies' used qualitative methodology gaining data "on how to incorporate interactive multimedia science software into the classroom, and observed a growth in various social and thinking skills that were developed and reinforced within the computer-supported learning environment (Poland et al. 2003, p. 229)."

Poland et al. (2003) illustrates, how among the identified factors contributing to the learning outcomes presented in the literature of these various studies proves items "such as instructional design features, enthusiasm, on-task behavior, cooperation and collaborative learning among students, attitudes towards science and the teacher's approach towards incorporating technology into the curriculum increases learning outcomes." (Poland et al. 2003, p. 229) Henderson et al. (2000) explains how the assessment of results of the existing literature on this topic connected to specific scientific instruction "would suggest that it could be used effectively" supporting "teaching and demonstration of important ecological fieldwork skills such as experimental design, ecological sampling, recording and analysis of data."(Poland et al., 2003, p. 229).

**Realities of CBI Instruction**

Over the last two decades in particular, literature increasingly demonstrates the ongoing importance of CBI teaching methodologies successfully enhancing academic outcomes that encompass scientific-based subjects for learners. Zeilinski and Swift (1997) explain the spread of CBI "has been important especially for difficult subjects in science…," instruction as well as enhancing scientific research. "Nowadays by using computers researchers studying molecular chemistry, medical chemistry, accounting for molecular orbitals are managing to ease collecting and processing data and gain speed (cited by Akcay et al, 2006)." While again, there exists a significant absence of literature about gender and racial assessments of benchmark testing among urban high school students and in particular the physical science field, the research does exist about the benefits of using CBI for scientific instruction as outlined by Akcay et al. (2006). The use of other kinds of CBI related technology including work by Yang and Heh (2007) adds another dimension to this inquiry according to the available literature.

Yang and Heh (2007) completed one study exploring the influence on the quality of learning by users of Internet virtual physics laboratory (IVPL) teaching and the outcomes of learning about physics and science process skills among a sampling of 10th grade students, and their attitudes about computers. Computer assisted instruction (CAI), according to Yang and Heh (2007) remains the focus of educational strategies using technology, with "a good computer virtual learning environments is an interdisciplinary product that merged the rational of science learning and educational technology." (Yang and Heh, 2007) Learning conditions created in this type of environment provide learners with both meaningful and active engagement because of the ongoing development of CAI -learning tools.

In response to these findings, the obvious lack of gender and racial comparisons among the learners poses an understandable scholastic demand for more inquiry directed research for this dynamic as a means for measuring the need for differentiation in the software design for optimum outcomes when measuring benchmark testing to related subjects including physical science instruction to urban high school students.

The results of this study proved the scale of differences in the IVPL instruction outcomes between the control and experimental group of students. "Because the IVPL can promote students' science knowledge and science process skills, it is an effective way to use the IVPL as a computer assisted learning environment for tenth graders to cultivate their scientific literacy." The findings also took into account the benefits of prior computer experience affecting the attitudes of students toward technologically-based instruction (Yang and Heh, 2007).

Yang and Heh (2007) researched and found the advantages of combining VRI technology with the pedagogical in science related problem-solving activities thus, creating a constructivist learning setting. Additionally, the same outcome proved the IVPL with the same advantages.

Implications of Yang and Heh (2007) study look at the benefits that secondary level science students gain from the IVPL use for instruction. Yang and Heh (2007 advise, "If we want to cultivate intelligent students and display the specific function of technology completely, the computer learning environment must provide every possible tool that could be used by students to collect intelligence distributed throughout their surroundings." (Yang and Heh 2007)

Recommendations in general, from the authors take into consideration how future CAI related domain progress needs to incorporate the collective existing wisdom for focused effort creating better analysis, design, development, and evaluation of both beneficial and pragmatic learning environments thus, maximizing the essential software and aligning it to the learning objectives. The literature remains scarce on studies focusing on specific gender related testing outcomes of high school science students from IVPL learning tasks but what findings exist in gender related attitudes about CAI learning provides a framework for implications connected to future studies on the topic (Yang & Heh, 2007).

The general knowledge of a learning environment teaching strategy using Web-based simulation (WBS) remains a "a powerful tool for enhancing inquiry learning process (e.g. de Jong & van Joolingen 1998; Kuhn et al. 2000; Abrams et al. 2001; Reid et al. 2003) (as cited by Pedaste & Sarapuu, 2006,)." Aligned to scientific study, a distinctive study provided by Pedaste and Sarapuu (2006) reported outcomes of the effectiveness of "small groups (of) students (who) learn effectively how to solve ecological and environmental problems" using WBI learning task. Other findings of this particular study show that only certain aspects of analytical skills among the sampling improved "without specific support." The implications according to these findings result, in recommendations using "a detailed analysis of the learning process" for increasing the WBI effectiveness. The findings of the study further established students' need for some type of

"additional support for realizing the potential of working in the … (WBI) … learning environment (Pedaste & Sarapuu, 2006)."

Aligned to the Pedaste & Sarapuu (2006) findings further reminds how learners constitute different cognitive abilities within the same community using WBI methodology for teaching any subject. Additionally, adding to these student characteristics are pre-skills, pre-knowledge, attitudes, and motivation. Prior to the use of CAI, teachers need to determine the varieties of difficulties each group of learners bring to the challenge of instruction. Recommendations connected to identifying specific needs and abilities among learning groups using the WBI or CAI teaching methodology therefore, includes grouping students according to these needs and abilities during learning tasks for differentiation in providing support.

Accordingly, Reid et al. (2003) described how teacher support during the WBI environment ideally directs focus on three areas including developing "meaningful, systematic, and reflective discovery learning." This process might then apply interpretative, experimental, and reflective type of assistant support. "Moreover, the support for building an inquiry learning strategy that takes into account multivariable causal reasoning and argumentative reasoning – the ideas of Kuhn et al. (2004), has to be based on the actual obstacles existing (as cited by (Pedaste & Sarapuu, 2006)." Clearly, the implications of using CAI as part of physical science learning strategy in older adolescents as a teaching methodology continues gaining merit, and with the input of Pedaste and Sarapuu (2006) as well as Nelson and Erlandsen (2007), investigations reveal guiding principles for teachers desiring implementing an engaging and effective learning strategy including physical science for urban high school students.

Work established in literature by McMahon (2010) further substantiates the view of the value of CBA instructional strategies. Urban secondary students learning physical science with

less emphasis on “authoritarian” instruction through the use of the “tacit” characteristics of a CAI structured methodology raising the potential for enhancing the learning experience and peer influence in the process. “There is clear evidence of increased higher-order cognition and motivation to learn among the participants within this virtual community (McMahon, 2010).” This furthers the evidence of the positive aspect of CBI strategies for engaging the learner in his/her own educational opportunities including physical science instruction. A sobering reality framing American secondary schools using CBI methodology of teaching is the consideration of the global perspective. The use of virtual schools among American students K-12 is more than one million (Means, Toyama, Murphy, Bakia & Jones, 2010; Cavanaugh, 2009). However, statistics prove on a broader international scale, “students using online courses continue outperforming American students according to testing outcomes per the Program for International Student Assessment and Trends in Mathematics and Science.” (Cavanaugh, 2009)

Borup, Graham, and Davies (2012) in their study of computer assisted instruction found participants showing learner-learner engagement scoring with a higher correlation to outcomes than the student interaction with the instructor or the course content. In this study, “Students’ perceived learning was not significantly correlated with any type of interaction, and only students’ total reported time spent on learner-learner interaction and students’ social learner–learner interaction were significantly correlated with their grade (Borup, 2012).” This further suggests the importance of teachers blending the learning experience according to a clear understanding of individual as well as collective learner emotional perspective of the teaching methodology and learners’ needs in this regard.

**Gender Preference in Related CAI Outcomes**

Gender continues proving a major factor in attitudes about CAI with existing studies showing young adult males (this includes older adolescent high school aged males) having a more positive view of computers in general but directly so as a learning tool. Connected to the literature on this aspect of CAI outcomes shows Ketelhut, Nelson, Clarke, and Dede (2010) in their study finding "girls tend to do worse than boys" connected to VLI for scientific inquiry (p. 66).

According to Comber, Colley, Hargreaves, and Dorn (1997) among a sampling of 278 high school students found the participating 15-16-year-old males reporting better experiences with computers and therefore had better attitudes about them related to learning in general than their female counterparts. International research on gender preference for CAI support with data from older findings on the subject published by research in the U.S. supports the male preference over females in ease of use, computer related self-efficacy, more self-confidence, and one study of British and Chinese on the topic showed the Chinese having less gender differences (as cited by Ashong, 2012).

Statistics of previous U.S. research outcomes on this subject according to Kay, (2008) reveal 30 to 50 percent of the literature proved aligned to gender on attitudes about individual computer ability, use, and preference going to male participants. Ten to 15 percent designated these characteristics align to female participants, while 40 to 60 percent of the studies reported no gender differences (as cited by Ashong, 2012). Another study provides data on gender differences in attitude about CAI learning strategies in general including science. The literature provides analysis of the way males and females approach academic instruction due to their learning style preferences (Ausburn, Martens, Washington Steele, & Washburn, 2009).

Lau and Yuen (2010) research results on the subject of gender and learning style preference derived from empirical methodology of their study. Testing "the sensitivity of a learning style instrument, the *Gregorc Style Delineator* (GSD)," the outcomes of their scientific investigation proved student participants among a Hong Kong secondary school sampling indicated computer science students showed differences according to gender. Female responses for the computer science course show gender related preference for abstract applications while males preferred the concrete random applications to this particular scientific field. "Pedagogical implications of gender differences in learning styles" which relates to females lack of confidence in CAI for other scientific based fields. One interesting outcome of the findings, according to Lau and Yuen (2010) connects to how, "Low participation of females and high attrition of students are currently serious threats to the development of related industries (Lau and Yuen, 2010)."

Cooper (2006) further argues on this timely view of older adolescent and young adult females' attitude toward CAI aligned to the field of computer science lagging behind male peers, there exist a serious outcome. Cooper (2006) advises, "Everyday, we risk losing the talents of women as contributors to science, technology, and the arts because the advantages that technology provide are being conveyed disproportionately to men in modern society (as cited by Lau & Yuen, 2010)." Therefore, the type of research provided by Lau and Yuen (2010) does provide better understanding of gender related issues in the science fields. They recommend science educators look at improving implementation of "pedagogical practices to narrow the gender gap (Lau and Yuen, 2010).

On gender attitude toward technology versus traditional assessed by a Raat and de Vries (1985) survey of a sampling of 2500 adolescent grade students' conception of technology

aligned to “machines or facilities (as cited by Chen, 2012).”Studies developed from these earlier findings, Hurley and Vosburg (1997) then determined a measurable connection existed between “student attitudes toward technology and learning attitudes toward emerging technology are positive and significantly correlated (as cited by Chen, 2012).

Mayring (1988) completed a case study forming the foundation of the methodology for testing gender perception of communication of students while participating in VSI learning environments by Stokar von Neuforn (2007). Mayring’s (1988) results derived from the sampling of:

> “A total of 256 students, 128 female and 128 male, participated in this (one) case study. In total there were 1537 different points made by the students, which were sorted into 50 different characteristics and split into four clusters (A –D) of text-based communication. In addition to the text-based characteristics, the participants also recorded examples and interpretations. These could then be evaluated, judging their qualities.” (As cited by Stokar von Neuforn, 2007, p. 210)

The need for reaching each student personally requires perceiving and gauging his/her individual learning gaps and emotional needs during the one-on-one interaction according to research focused on gender differences (Stokar von Neuforn, 2007). As instructors, according to Stokar von Neuforn (2007), “These factors of learning motivation depend on the individual perception of virtual, text based communication. The coding and encoding of purely, text-based language requires an enormous amount of compensation with regard to the absence of all verbal means of communication (Stokar von Neuforn, 2007).”

Consequently, this focuses on determining the presence of “any gender differences in the compensation for non-verbal communication or in the perception of text-based communication.” Stokar von Neuforn (2007) outlined the gender gap among participants in his investigative work aligned to male and female “perception of text-based communication” in the study evaluation. As a result, assessment of the research outcomes determined the majority of female participants’

individual production and perception of text-based communication decreased in virtual learning environments (Stokar von Neuforn, 2007).

Research objectives defined the attributes of text-based communication indicating gender differences of the participants involved in VSI environments. The results of this study provide information in relation to individual gender reactionary understanding and ensuing production of both written messages and the application of measures supporting his or her learning motivation according to Stokar von Neuforn (2007). In their earlier work Stokar von Neuforn and Thomaschewski (2006) found the relevant factor underlining VSI learning success connects to what participants "receive and which learning atmosphere he or she is currently in ( as cited by Stokar von Neuforn, 2007)."

Finally, Stokar von Neuforn (2007) recommends the importance of instructional "conscious observations of text-based communication styles could help in recognizing and taking into consideration the interpersonal and gender gap aspects of messages." Additionally, instructor "sensitivity to the presence of personal and emotional information can help overcome the gendered, interpersonal barrier which arises from gender differences." Successful use of VSI strategies connecting to teaching physical science among urban high school students according to this particular research outcome looks at "explicitly formulating text-based characteristics which can be considered as essential clues in the interpretation of the interpersonal aspect within written communication (Stokar von Neuforn, 2007)." With the realities of the 21st century technology underpinning growing use of CBI in all fields of academics, consideration of identified gender differences creating gaps in successful outcomes for all participants therefore, must consider such defining research as this in applying technology in the classroom.

Further evidence of the gender characteristic proving the existence of male and female gaps in quality of learning emerges in the literature published by Ming, Tutwiler and Chun-Yen Chang (2012). In their publication of their findings they explain how the data allowed them a better understanding of the connection between using virtual environments in science education and user perception of assistance, and how the two relate to male and female participants. Males in the study showed better results measured comfort of navigation than females. According to literature of  Chou & Tsai, 2007; Desai, Krishnan-Sarin, Cavallo & Potenza, 2010; Hoffman & Nadelson, 2010; Ogletree & Drake, 2007) "performance" (eg, Brown, Hall, Holtzer, Brown & Brown, 1997; Feng, Spence & Pratt, 2007), report gender-based differences across various cultures (as cited by Ming et al., 2012). "Be aware that females may perceive and use your system differently than males, and ensure that your design choices accommodate both. In addition, we encourage future research exploring this problem gap (Ming et al., 2012)

.

**Racial Comparisons**

Based on the national popularity of older adolescent college students taking astronomy at some point in their first years of college, a study of 2000 students from across the country enrolled in 69 different astronomy courses answered a survey specific to identifying demographics including race. This focus on personal and family characteristics of the participating students looked at determining any gaps according to the demographics including race aligned to learning outcomes of studying astronomy in a traditional teaching methodology environment and one engaging learners in the use of VSI technology. Outcomes of this study showed African Americans, Hispanics, and Asian Americans taking the Astrology course in first

year-college reflect the national racial statistics (Rudolph, Prather, Brissenden, Consiglio, & Gonzaga, 2010).

Gender, age, race, or nationality research in traditional classroom instruction shows a measureable amount of literature. Graff (2006) reports on studies of learner participation with on line instructional tasks (as cited by Coldwell, Paterson, & Mustard, 2012). "However, there is a lack of research into whether, and how, demographic factors affect students' participation and performance in an online learning environment (Coldwell, Paterson, & Mustard, 2012)." Consequently, what the literature shows about diversity, including race, physical science education, and the connection to on line instruction remains as part of the substantial body of areas linked to CBA teaching strategies and are in need of research.

**Cultural Aspects**

Data derived from one study measuring quality of perception according to the culture of users engaging in online education provides further insights. Integration of both students' and teachers' experiences from increased incidents of using virtual instructional technology shows the relevancy of such teaching/learning tactics. According to Milano (2008) as well as revealing "the existence of potential cultural differences. By simply recognizing these differences, teachers will be able to face them and consequently to optimize their teaching and learning practices." (Milano, 2008). The study attempted identifying teachers' perspectives connected to cultural varieties for differentiating the online instructional materials accommodating all learners' needs

Results of the findings conclude that this remains an uncharted area of understanding about on line education. Milani (2008) concludes more research remains essential for

substantiating specific influences needed for online module development for instruction across all fields of study relating to the cultural diversity of the participating learners.

**Discussion/Conclusion**

Reflection on the literature review compiled in this section of the research agenda centered on identifying and thus reporting the comparative outcomes of CBI strategies in teaching applications in lieu of using traditional classroom teaching methodologies for instructing physical science to suburban high school students. The preceding literature review shows different and important aspects about 21st century education typical use of SVI and CBI based schemes for teaching physical science to urban high school students. Huang et al. (2009) designate how the comparison of virtual reality technology (VRT) used for instruction across the board for all subjects including physical science when compared to the majority of VRTs both facilities and the resources of high schools remain limited. This connects to the fact using CBAs with instructing high school students requires they "be seen as beginning learners in dynamic digital technology (as cited by Chen, 2012)."

Linked to this reality, Huang et al. (2009) describe how the arrangement of a CBA module design must correspond in the areas of "subject matter, learning process, and technological content" from a pragmatic perspective. In doing so, this reduces the instructional attention focusing on the more problematic aspects of learning abstract theory using this form of CBA instructional content. Once students gain a solid practical background experience operating learning tasks using CBAs then teaching theory follows instructional strategies using the VRTs (as cited by Chen, 2012).

Two inquiries prodded this investigative literature review. As stated in the introduction the first of these questions underpinned researching the literature determining to what extent gender difference in achievement on benchmark testing with learners receiving SVI exists. In doing so, the prevalence of among the prevailing data reveals more published studies on the importance of gender "attitude" toward CBI learning rather than target test outcomes based on gender difference among physical science students as previously stated. The second inquiry of this research has a better showing of published conclusions determining significant differences in achievement on benchmark testing of students receiving SVI focusing on racial demographics including African American, Caucasian, and Hispanic than, again, gender differences.

The lack of definitive literature in abundance addressing both gender and racial demographics as bench mark measurements for achievement among high school students using CBI based instruction of physical science (as well as other subjects) leads to the assumption this under representation in the literature lends to the fact the use of CBIs as instructional options took longer to develop software as reported by California State University Long Beach describes only between 1997 and 2007was educational software developed as both useful and interesting to students for engaging them in the learning process as designers incorporated more graphics and video interaction (2008).

The literature as shown, describes research on CBI use in teaching high school and early college instruction including science with attention on gender "attitudes" toward the use of SVIs. The abundance of research on teaching CBI based instruction shows only slightly more literature available for the racial breakdown of academic achievement among high school or young adult learners as part of the third adolescent group of students in comparison to the sorely lacking literature on gender according to benchmark testing assessments. The significance of the gender-

related “attitude” towards engaging learners in the use of CBI teaching strategies looks at the biological, emotional, and cognitive development linked to computer use proficiency for learning different subject related technologically based task.

At this point, discourse in this section of the literature review presented poses the relevancy question of software design including differentiation options for users accommodating the diversity of the classroom in the 21st century. The literature on the traditional classroom instruction of all subjects including physical science providing differentiation options in the instruction to meet all the needs of a diverse classroom continues growing. The lack of this connecting to the specifics of gender and race in the literature and the use of CBI for instruction of (i.e.) physical science therefore proves understandable.

As importantly, amid the bulk of the literature this scholastic endeavor identified in connection to the focus of this particular research on CBI relating to high school physical science teaching comes back to the teacher perspective as much as the student outcomes among the target group of urban high school physical science students. Henderson et al (2000) address this with recommendation that even more research take place identifying “how teachers incorporate computer-based instructional technology into the curriculum … (as cited by Poland et al., 2006)” linked to teaching physical science.

The lack of literature providing substantive findings linked to the gender and racial benchmark assessments with the use of CBI technology in teaching therefore, must additionally consider how “the context of virtual learning environments (stand as a) relevant factor for success of the participants… (According to) what they receive and which learning atmosphere he or she engages according to Stokar von Neuforn and Thomaschewski (2006a, b) (as cited by Stokar von Neuforn, 2007).”

In conclusion, this scholastic focus on investigating the available literature from studies substantiating direct data linked to the research agenda of this academic project centered on identifying and thus reporting the comparative outcomes of CBI strategies in teaching applications in lieu of using traditional classroom teaching methodologies for instructing physical science to suburban high school students fell short. In addition, inquiry of the existing literature proved lacking in substantial research on gender and racially related assessment of benchmark testing outcomes among urban high school physical science students. Nonetheless, the available literature does validate relevant implications for further study with the abundance of literature proving the continued successes of CBI in general as a teaching strategy for all subjects but as linked to this discourse the use of it for instructing urban high school students in physical science.

The need for further studies identifying gender and racial markers connected to assessment of benchmark testing of students learning CBI physical science teaching exists. In addition, this lack of information shows the need for such information for creating better CBI software that reflects teaching options for differentiating presentation of the material according to the demographic needs of the typical diversity found in classrooms no matter the subject in the 21st century.

The technology driven 21st century importance to educational goals for all fields of study but particular to science instruction among urban high schools students must address the changing global community that reflects the typical classroom setting in diverse representation as shown by the demographic realities high school teachers remain increasingly challenged with each ensuing new school year. The future of educational research now exhibits a particular niche within the technological categories that must include the need for identifying markers indicating

both the gender and racial standing of benchmark testing assessments linked to all subjects but as aligned to this academic project to the urban high school physical science student outcomes.

# CHAPTER III Methodology

## Introduction

The research methodology is adapted to this research but similar to several other research studies published in peer-reviewed journals comparing computer aided instruction vs. traditional direct instruction. (Aqda, Hamidi, & Rahimi, 2011, Chai, Koh, & Tsai, 2013, Chang, Yuan, Lee, Chen, & Huang, 2013; Hwang, Sung, Hung, & Huang, 2013; Sauter, Uttal, Rapp, Downing, & Jona, 2013). Researchers recommend more research on student learning and computer technology (Chai et al., 2013; Hwang et al., 2013; Lei, Lin, & Sun, 2013; Rushby, 2013).

Sauter et al. (2013) put the recommendation in terms of researching the best strategies for developing the “most effective learning environments possible” by integrating CAI. Prather, Consiglion, Rudolph, and Brissenden (2011) conducted a USA national study concluding that the

demographics do not prevent "effective implementation of interactive learning strategies." Lei et al. (2013) found that effective reading ability is beneficial to students' learning experiences with CAI. The researcher proposes to compare CAI simulations versus traditional direct laboratory instruction (TDI) with two separate participant groups taking secondary physical science.

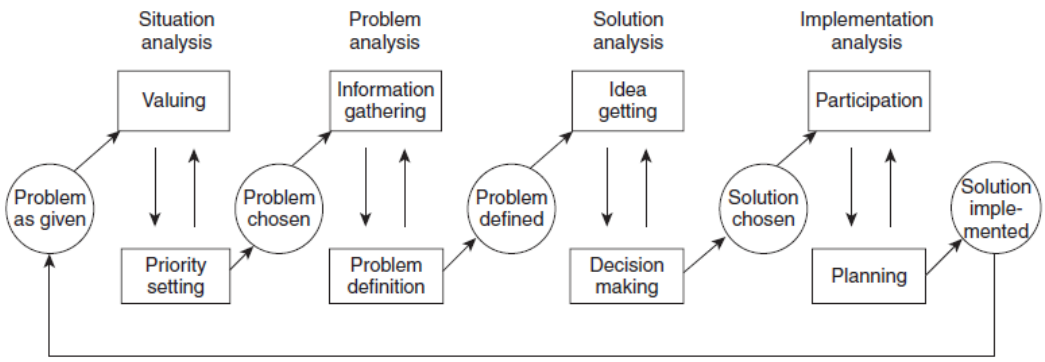



**Figure 3. (Kolb 2013)**

**Research Questions and Hypotheses**

Research indicates that CAI can affect learning for students of all ages in a variety of content areas, but the topic is complex and many other aspects remain to be added to the pool of knowledge. The research on computers in the classroom is very limited for virtual labs or simulations being compared to traditional labs and evaluated measuring student achievement with benchmark testing. The topic of this research is timely because it seems that many virtual laboratory simulations for the sciences are being published on the web covering topics from Astrology to Zoology. The primary research question concerns virtual simulations and their significance for learning compared to the same subject being taught, using a traditional laboratory practicum.

**Main Research Question**

Is there a difference in science achievement between students who are taught using virtual simulations (CAI) versus students who are taught using traditional lab instruction (TDI), as measured by unit benchmark testing?

**Research question 1 and Related Hypotheses**

**1.** To what extent do the results of benchmark test differ between students who receive supplemental CAI labs and the same students who receive traditional lab instruction, after controlling for pre-achievement test scores?

$H1_0$: There is no difference in achievement on benchmark test between students receiving supplemental CAI simulations and labs and students who receive traditional lab instruction, after controlling for pre-achievement test scores.

- DV: Achievement
- IV: Instruction type (virtual labs/simulations and traditional method instruction)
- Covariate: Pre-achievement
- Statistical Analysis: ANCOVA

**Research Question 2 and Hypotheses**

**2.** To what extent does science achievement on the benchmark test differ between students receiving supplemental CAI simulations and labs and students who receive traditional lab instruction, after controlling for pre-achievement test scores, moderated by gender (male, female)?

$H2_0$: Differences in achievement on the benchmark test between students receiving supplemental CAI simulations and labs and students who receive only traditional lab instruction, after controlling for pre-achievement test scores, are not moderated by gender (male, female).

DV: Achievement

IV: Gender (male, female)

Covariate: Pre-achievement

Statistical analysis: ANCOVA

**Research Question 3 and Hypothesis**

3. To what extent does science achievement differ between students receiving supplemental CAI simulations and labs and students who receive traditional lab instruction, after controlling for pre-achievement test scores, moderated by ethnicity (African American, Caucasian, Hispanic, and Asian)?

$H3_0$: Differences in achievement on the benchmark test between students receiving supplemental CAI simulations and labs and students who receive traditional lab instruction, after controlling for pre-achievement test scores, are not moderated by ethnicity (African American, Caucasian, Hispanic, and Asian).

DV: Achievement

IV: Ethnicity (African American, Caucasian, Hispanic, Asian, or Other)

Covariate: Pre-achievement

Statistical analysis: ANCOVA

**Variables**

**Table 3-1 Hypotheses linked to the variables the covariate**

| Hypotheses | Dependent variable | Independent variable | Covariate | Statistical analysis |
|---|---|---|---|---|
| H1 | Achievement | Instruction type | Pre-achievement | ANCOVA |
| H2 | Achievement | Gender | Pre-achievement | ANCOVA |
| H3 | Achievement | Ethnicity | Pre-achievement | ANCOVA |

The dependent variable is achievement and its covariate is pre-achievement. (See table 3) Each hypothesis presented above assumes the same dependent variable and covariate. The independent variables are (a) instruction type, CAI or TDI, (b) Gender, gender of male or female, and (c) ethnicity, ethnic or racial backgrounds. Gender and ethnicity are the variables that gives demographic information.

**Statistical analysis: ANCOVA**

This research involves students assigned physical science classrooms with different levels of pre-achievement, or a covariate. "The presence of covariates reduces the ANCOVA error variance and offers a more sensitive test for the hypothesis that the group means of the dependent variable do not differ." (Rheinheimer, 2001) This correlates to this research as earlier CRCT tests will be used to measure the preexisting academic level of the students in the class. The comparisons can be made directly without adding a third result from a different type of statistical analysis. Using a different statistical analysis would require comparing results that were produced using different methods, and the ANCOVA offers the major advantages over analysis of variance (ANOVA) of greater statistical power and a reduction in bias. (Rheinheimer, 2001).

"ANCOVA can also be used to adjust for bias in observational studies." (Belin, 2009) "Bias can occur if there is little or no overlap in the distribution of covariates among groups of individuals receiving different exposures, in which case inferences about exposure effects will be very dependent on assumed extrapolation of trends across the ranges of observed covariates." (Belin, 2009). Belin states that validity and bias can be preserved by defining an effective treatment. "A treatment or intervention is typically declared effective if clinically meaningful treatment effect sizes arc observed and if statistical significance is demonstrated at some prespecified alpha level." (Belin, 2009)

The ANCOVA is a good research choice is because it is the statistical model that includes covariates. How the statistical analysis ANCOVA performs will be discussed in detail below but generally speaking it is a sub-model of ANOVA that evaluates covariates. "ANOVA is a natural research tool that uses logistic regression to investigate treatment effects controlling for background characteristics and can similarly be extended to other outcome measurement scales." (Belin, 2009)

This research is measuring the gain in student achievement by pre/post benchmark testing. "When pretest data are available the method of analysis of covariance (ANCOVA) is often used for estimating the treatment effect and for inference." (Ganji, 2004) By creating a baseline for each student the ANCOVA will measure the students' achievement against the predetermined baseline for each student. Ganji states, "The pretest variable is assumed to be a constant measured without error. Results from a regression analysis are conditional on the observed covariate." (Ganji, 2004). These facts formed the decision to use the ANCOVA statistical methodology for this research. It will compare virtual lab instruction to traditional lab

instruction, measuring the gain in science achievement, after establishing the students' baseline on a diagnostic test while using prior standardize achievement as a covariate.

**Research Design**

Students will be invited to participate in the research after they have registered for one of the physical science classes during class registration. The students, with parental consent that agree to participate will be assigned student numbers to protect their personal information. The student numbers do not give any indication of gender or ethnic background so coding the test results for each participant will only be a numerical value. Two demographic variables will be measured, gender and ethnicity to determine if gender or racial culture has an influence on science achievement. The use of gender and ethnicity in this study is part of the participation agreement.

The two participating groups will be learning the same material from six science units so the learning materials are exactly the same and the learning activities are the same. Three units will be taught using traditional lab instruction and three units will be taught using virtual laboratories as the laboratory practicum. Both classes will serve as the control group and the experimental group, so that every student is exposed to the treatment, and every student has the opportunity to benefit from the study. The benchmark measurements will be carried out by administering a pretest on the concept area and a posttest after the unit ends. Statistical evaluation of the data will be carried out using the Analysis of Covariance (ANCOVA) software. The covariant in the study is independent of the other variables. ANCOVA will be used to evaluate the results pertaining to the intermediate learning of both groups.

Validity and reliability need to be measured for the data because the numerical values indicate bias (Creswell, 2003). "Competent inquiry" must provide calculations on validity and reliability to demonstrate their ability to meet scientific standards (Creswell, 2003, p. 8). "There are two major assumptions that underlie the use of ANCOVA; both concern the nature of the relationship between the dependent variable and the covariate."

(Vogt, 1999). The first assumption is that the relationship between the dependent variable and the covariate are linear. "If the relationship is nonlinear, the adjustments made in the ANCOVA will be biased." (Vogt, 1999) This research will use a factorial design and analyze how three variables effect a dependent variable, science academic achievement.

"ANCOVA's validity requires a random sampling from the population of interest." (Breukelen, 2006) "Most research completed at American and European Universities use convenience samples of an undergraduate population that are generalized to the western world." (Rutherford, 2001) A quasi-experiment requires evaluating the causal effect of an intervention on a population. The target populations in this research are the students who take units with CAI and then units with TDI. Internal validity needs to be designed carefully (Dinardo, 2008). The validity of this research is predicted to be good because control variables are identified and designed into the research. With only random data and no controls the possibility to carry out an experiment with non-valid results is a concern because of the quasi –experimental nature of the research. The degree of freedom needs to be immersed into the calculation and the probability is the output that indicates the validity of the data. (See table 3-3)

**Table 3-3**

| |
|---|
| $P < 0.05$ statistically significant |
| $P < 0.01$ |
| $P < 0.001$ statistically highly significant |

**Population**

Students make up the population of the study because the task is to measure the difference in achievement using different laboratory approaches. The students registered in two identical science laboratory classes will be invited to participate in the study. The students who accept the invitation will form the research group.

**Participants**

The population for the study will be students whom are registered for physical science and accept the invitation from the researcher to participate in the study. Both classes will be organized to follow the same format. The students in each class will be taught six instructional units. Three using a traditional laboratory approach, and three that use a simulation approach. Before and after each unit, a benchmark test will be administered to measure the gain in achievement. The benchmark test will be the research instrument used to measure the academic achievement from the units and to review data on past CRCT benchmarks to evaluate pre-achievement.

**Research Purpose**

The primary research purpose is to analyze if any significant difference exists concerning students' achievement using technology to supplement physical science instruction. The

measurement tool to be used in this research is diagnostic testing followed by a post test for each unit of study. The pre/posttest format will measure academic achievement, with the research analyzing any differences between traditional laboratory practicums and virtual simulations supplementing these units of instruction. The effectiveness of technology needs to be measured by using performance benchmarks, because it will numerically evaluate student achievement. Benchmark testing and data from previous Criterion-Referenced Competency Tests (CRCT) are to be used in this research to establish prior student achievement, which will establish the covariate for this research. Benchmark testing is used by teachers to assess student achievement during the school year so the teachers can monitor student learning. Sometimes benchmark testing is used to (a) "measure student growth" and (b) "design curriculum to meet individual learning needs" (Coffey, 2011). A direct comparison of students' achievement during three units of physical science class using a traditional laboratory experience; followed by three units of physical science with a virtual laboratory experience will evaluate if there is any significant difference in achievement between the two supplemental laboratory strategies.

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**Table 3-4 Research Plan**

| Phase | Steps | Activity |
|---|---|---|
| Phase 1 | Step 1 | During student registration, students who register for the two physical science classes will be invited to participate in the research while taking their class. |
| | Step 2 | The students that accept the invitation will compose the population of the research study. The students will be assigned numbers for the purposes of the research so that personal information like name, address, phone numbers, etc. are kept private. |
| | Step 3 | CRCT scores will be collected during this phase of the research. The purpose of collecting the CRCT scores is to establish pre-achievement values. |
| Phase 2 | Step 4 | *Before the first unit* is taught in the class the research population will take a benchmark test to assess their prior knowledge. |
| | Step 5 | *Two weeks later* the research population will be asked to once again take the same test as a post-test, in order to asses their achievenment at the end of the first unit. |
| | Steps 6 to 11 | *Every two weeks after*. The number of units taught during the class totals six units. The post-test for the unit was given to the students in Step 5. A post-test will be given every two weeks at the end of the five remaining units |
| Phase 3 | Step 12 | At the *conclusion of the class*. At the conclusion of the class each member of the tests will given to each member of the research population that covers the three units that used TDI only. |
| | Step 13 | At the *conclusion of the class*. At the conclusion of the class each member of the tests will given to each member of the research population that covers the three units that used CAI. |
| Phase 4 | Step 14 | The results will be categorized and organized so that input can be made into ANCOVA. |
| | Step 15 | ANCOVA will be used to run a statistical analysis of the input values. |
| | Step 16 | The values and data output by ANCOVA will be evaluated. |
| | Step 17 | Study conclusions will be written and a report of the research results will be prepared. |

## Research Method

This research study is based on the quasi-experimental quantitative research method. The computer models ANCOVA and SPSS will be used to analyze the data collected during the experiment. The measurements are of the variable and the data will be analyzed by the ANCOVA statistical model and graphed using SPSS software. SPSS is designed to graph multiple linear regression outputs and to offer other analysis results in a table form. Quantitative variables must be data or values that can be grouped, but they are not necessarily numerical. To give quantitative variables a value the variables are coded (Aliaga & Gunderson, 2002). A common example of coding gender is to assign females a code of one and males a code of two (Aliaga & Gunderson, 2002). The larger the number of variables, the more complex the coding becomes.

The performance benchmarks need to be assessed by controlling outside variables that include prior content knowledge, reading levels and other pre-achievement variables. The assessments are necessary to learn whether technology is an effective teaching tool for every student. The literature suggests there is a lack of data comparing benchmark testing outcomes between TDI versus CAI. Research evaluating the direct comparison between instructional methods by conducting analysis of student achievement is needed. Therefore this research will generate data measuring the student achievement involving technology and comparing it to a traditional laboratory experience. The data will be reported for the two types of learning experiences as CAI and TDI. The same types of statistical analysis will be used in both groups and presented for analysis.

An element of qualitative methodology incorporated into the research is defining the ethnographic location of the study as the classroom. (Fashola, n.d., p.7). The location of the research implementation is significant; student-learning inside the classroom is the setting instead of a location unrelated to the normal daily routine of student learning in school (Kinshuk, Huang, Sampson, & Chen, 2013).

**Table 3 5 Item Analysis**

| **Item Analysis** |
|---|
| **Item Pre-and Post-Achievement Tests Research Question 1** |
| **Analysis** Learning Achievement before new lesson |
| How do the results of benchmark test differ between students who receive |
| supplemental CAI simulations and labs and students who receive only |
| Traditional lab instruction, after controlling for pre-achievement test scores? |

| Item Analysis |
|---|
| **Reference** Sauter, M., Uttal, D. H., Rapp, D. N., Downing, M., & Jona, K. (2013). |
| Getting real: the authenticity of remote labs and simulations for science learning. |
| Distance Education, 34(1), 37-47. |
| doi: Doi 10.1080/01587919.2013.770431 |
| |
| **Item Comparison of CAI and TDI Research Question 3** |
| **Analysis** Moderated by ethnicity |
| To what extent does science achievement differ between students receiving |
| supplemental CAI simulations and labs and students who receive only traditional |
| lab instruction, after controlling for pre-achievement test scores, moderated |
| by ethnicity (African American, Caucasian, Hispanic, and Asian)? |
| **Reference** Aqda, M. F., Hamidi, F., & Rahimi, M. (2011). The comparative effect of |
| student's creativity computer-aided instruction and traditional teaching on |
| in math classes. Paper presented at the Procedia Computer Science. |
| |
| **Item Comparison of CAI and TDI Research Question 2** |
| **Analysis** Moderated by gender |
| To what extent does science achievement on the benchmark test differ |
| between students receiving supplemental CAI simulations and labs and students |
| who receive only traditional lab instruction, after controlling for pre-achievement |
| test scores, moderated by gender (male, female)? |
| **Reference** Lei, J. (2010). Quantity versus quality A new approach to examine the |
| relationship between technology use and student outcomes. British Journal of |
| Educational Technology, 41(3), 45 5-472. |
| |
| **Item Benchmark tests Research Question 1** |
| **Analysis student achievement** |
| Is there a difference in science achievement between students who are taught using |
| virtual simulations versus students who are taught using traditional lab instruction, |
| as measured by unit benchmark testing? |
| **Reference** Coffey, H. (n.d). Benchmark assessments. Learn NC. |
| http://www.learnnc.org/lp/pages/5317#note1 |

## Research Theory

### Knowledge Acquisition

The new technology featuring computers, the Internet, software and Smart Boards are giving individuals a new way to construct meaning. Many sources are now available to add to our knowledge that allows us to understand concepts.

> Constructing meaning from multiple information sources denotes a new form of literacy, which involves locating, evaluating, and using diverse sources of information, digital as well as printed material to construct an integrated, meaningful mental representation of a particular issue, topic, or situation. (Seel, 2012, p. 1677)

### Ethical Considerations

Ethical values have a significant place in research because the purpose is to protect the rights of the participants and maintain privacy of their personal information. The personal and identifying information for every participant will be coded to protect confidentiality. The results will be presented in aggregate form. The aggregation data is useful for evaluating the data in quantitative methods similar to the use of groups of observations in qualitative methodologies (Garbarino & Holland, 2009, p.11).

The guidelines of the university will be followed carefully to eliminate bias towards any participants or towards either teaching method. The study procedures and data management processes will be approved by Columbus State University's Institutional Review Board and the cooperating school. An activity that falls under the heading of ethical consideration will cause no risk or harm to the students who participate and protect their privacy. Other activities

generally covered in ethical considerations are parental consent, permission to collect data, and permission to share data (Fashola, n.d., p.7). The parents of the student participants will be sent an informed consent form and information about the research so that they can make an informed decision whether or not to sign the consent form. An explanation of the purpose of the study, the design of the study, and assurances about the risks and benefits of allowing their child to participate will be included. The letter to the parents explains that their child will not experience harm, and that the child can withdraw or be withdrawn from the study at any time without penalty. Parents will give written permission for their student to participate in the study, if not the student will not participate.

**ANCOVA**

The ANCOVA will be used to statistically assess the differences in the students' academic achievement for each group. This is the purpose of ANCOVA; to compare the differences of means among two or more groups. "Although it's inevitable that the covariates and experimental conditions will share some sort of conceptual link, traditional ANCOVA assumes that the covariate(s) will not influence the nature of the experimental conditions." (Rutherford, 2001) The sample is expected to differ because of the research design, the large variety of environmental variables that can be measured and differences between learning styles and demographics of the student participants. Differences in results are referred to as sampling error or as how randomness affects outputs.

**Similarities and Differences**

ANOVA and ANCOVA are closely related because ANCOVA is a type of ANOVA that can evaluate studies that include covariates. ANOVA generates both linear and nonlinear

models; ANCOVA generates linear only. ANOVA does not take into account covariant. ANCOVA must be used when a covariant or co variants are part of the research, because ANOVA does not have that capability. ANOVA is the analysis of variance whereas ANCOVA is the analysis that includes a control variable so a covariance calculation must result. ANOVA is based on three fundamental assumptions (a) the response are normally distributed, (b) data points are independent of each other, and (c) the variance does not demonstrate a large difference within-groups.

**ANCOVA**

The ANCOVA statistical model handles "a quantitative outcome (with) two explanatory variables, one categorical and one quantitative . . . the quantitative explanatory variable is considered to be (the) control variable" (Seltman, 2014, p. 246). In the ANCOVA software the independent variables are labeled categorical variables; in this research they are (a) the instruction type, (b) the gender of the participants, and (c) the ethnicity of the participants. The dependent variable is considered a continuous dependent and in this research it is achievement. The covariate in this research is the students pre-achievement.

This research must use ANCOVA because the covariate, 'pre-achievement' is part of the research design. In this research, the variable 'pre-achievement' is the control variable used when testing all three of the research questions. The measure for determining pre-achievement is data from the statewide CRCT test. The pre/post tests will measure the students' achievement before and after each unit in both of the physical science classes.

The statistical model, ANCOVA evaluates the data and then, reports the results as the variances between the means of the groups studied in the research. The word 'means' is used instead of average, but in this case the definition is the same. The mean of the data is the

numerical value that is calculated after a set of data is added together and divided by the number of data, in other words the average value. A list of data is averaged and then used as a measure of variance. The variance is the distance a data point is located from the mean.

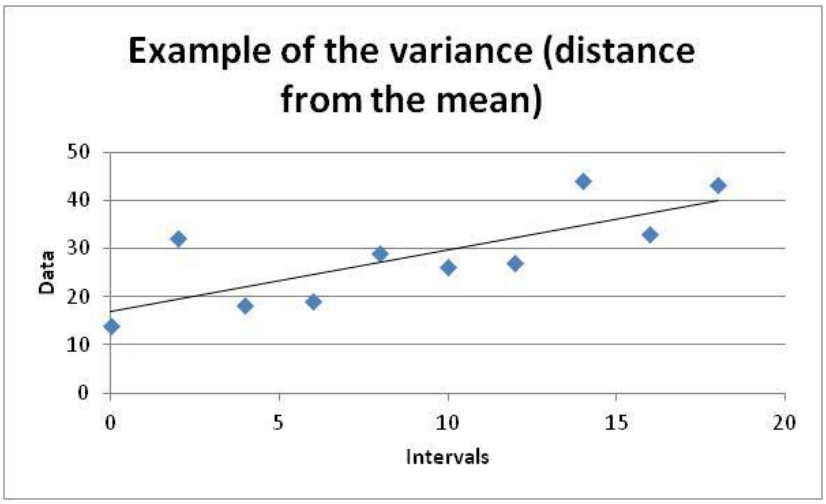



**Figure 3-5 Example of the variance (Author)**

The variance is the amount of distance a data point is located from the average value that was calculated from the data set. Figure 3-5 shows an imaginary data set as an example of what is meant by 'variance from the mean.' The mean is represented by the straight line running between the data points. The variance of the data points refers to the distance each data point is located from the line. The data point that represents 29 is sitting on the line because the average of the data set is equal to 29.

ANCOVA is a statistical analysis model that outputs the results of the analysis in tables. SPSS is useful for graphing the output of ANCOVA. A scatter plot of the data will show where each data point is located with relationship to the y-axis and to the x-axis. The first step for making figure 3-5 was to make a scatter plot of the data points; the data points seem as if they

are scattered across the graph without any reason. The next step was to add the linear regression which is the line added to the graph.

**Data Analysis**

Knapp states, "The gain score from pretest to post-test and ANCOVA can yield disparate results which was the case made by Lord (1967) and is known as Lord's paradox." (Knapp, 2009). The use of both the pre-posttest and the ANCOVA implies different perspectives of the research question being posed. "What is the effect of the treatment change from pretest to posttest? The ANCOVA analyzes what effect of the treatment on the posttest is not predicted by the pretest?" (Knapp, 2009) "The within-group sample sizes are an important variable in ANCOVA simulation studies because of their relationship to the power of the test and their interaction with group variance inequalities." (Rheinheimer, 2001) The within-group differences are the data points in one data set; the within group differences are how the data points vary from each other.

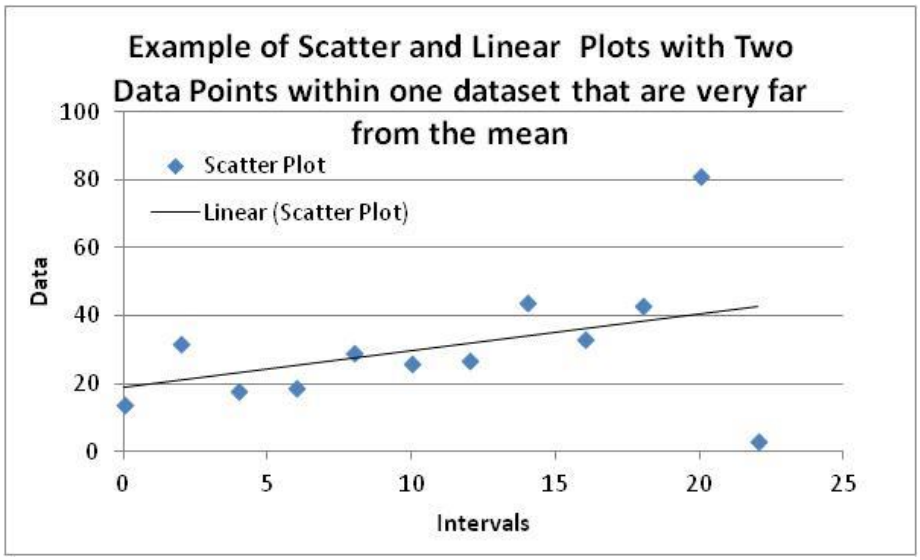


Figure 3-6 is an example of another graph of within-group differences in a data set. Two data points lay a long distance from the mean. On the bottom right is the data point where x = 22 and y = 3; at the top right is the data point where x = 20 and y = 81. The ANCOVA analysis will determine if they are too far from the mean to be included in the data set or because they are outliers they are not appropriate to use in the calculations.

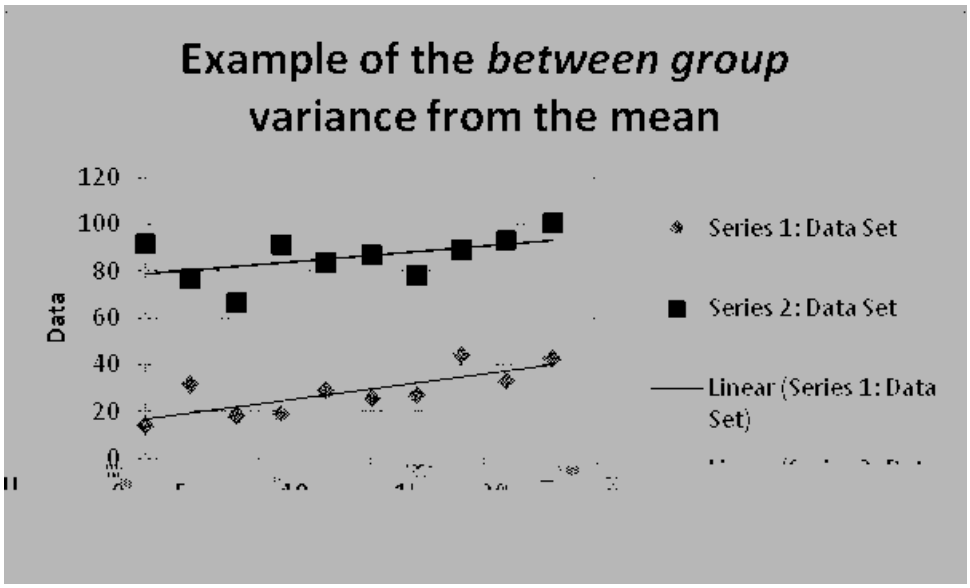



**Figure 3-7 Example of between group variance from the mean**

Between-group differences are also calculated to determine the F ratio. In the graph depicted with figure 3-7, the difference between the means of the two data sets can be seen visually. The means are far enough apart that there is not over lay between the data points between the two data sets. Series 2 Dataset is more than 60 measurement units higher than the Series 1 Dataset. Figure 3-7 is showing the difference or variance between the means of two groups.

Probability is reported with the P-value, *p,* and is defined as the probability of obtaining an F ratio equal or approximately equal to one. The larger the numerical value of the F ratios, then the smaller are the P-values, that is *p= probability* is smaller (Hindle, 2013).

**Probability**

The probability of an event happening, *p,* is the measurement of significant difference between the groups of data; the groups are compared in pairs in order to determine probability. The range that a data point will give a specific value has the probability of taking place is between 0 and 1. The closer *p* is to 0 the lower the probability an event will take place, while on the other hand the closer *p* is to 1 the chances of the event taking place are higher. A value close to 0 is when $p = 0.05$ or 5 percent; a value close to 1 is when $p = 0.95$ or 95 percent. Probability is reported as the P-value or *p*. When *p* is found to be less than 0.05 ($p < 0.05$), then the probability indicates that the mean of one group differs significantly from the other group.

**Assumptions of Linear Regression**

Linear regression is the same as the lines that were drawn in the four graphs above. In other words, linear regression is the link or relationship between the mean value and the values of the data points. "When the assumption of parallel regression slopes is made, differences in the response variable among treatments are the same at all values of the covariate." (Barrett, 2010) Barrett further states: "Means adjusted for differences in the covariate can be calculated and treatment differences are assessed by testing for differences in adjusted means." (Barrett, 2010)

The linearity of regression is possible when the relationship between the independent and the dependent variable are linear.

**Homogeneity of variance**

Homogeneity is from the Greek language where ‘homogenies’’ means the same kind. “When the assumption of homogeneity of regression slopes is not met, ANCOVA cannot proceed as adjusted treatment means cannot be correctly interpreted.” (Barrett, 2010) So logically the homogeneity of variance means that the values for the variances are in the same range, and the outlier data is eliminated.

**Assumptions of normality**

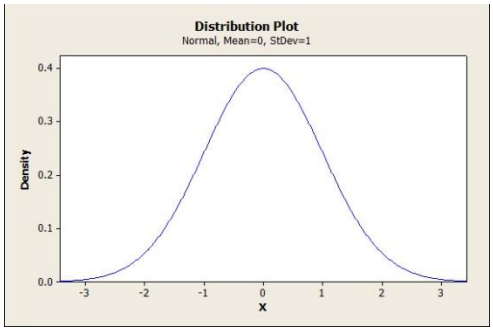



**Figure 3- 8 Graphic representation of normal distribution (The Minitab Blog, 2011)**

Normality can be considered numerically or graphically. The graph above, if folded in half, can be shown to be perfectly symmetrical. The normality of a normal distribution of data point’s results in a graph called the bell-shaped curve. It is an upside down bell-shape with a mean (peak) at zero and a standard deviation of one. The peak is the highest point on a graph; the data point with the highest value. The standard deviation is the distance from the mean that the data points fall. The standard deviations are compared between the two groups of the research study during the statistical analysis

**Summary**

The research design is structured to meet concerns about validity and reliability. Benchmarking in the form of pre-achievement and post-achievement tests will be given. Other research studies and interventions were carefully reviewed in order to produce an appropriate research design. ANCOVA is the statistical model that will be used because the research uses covariates as control variables. Three hypotheses are to be explored and each uses achievement as the dependent variable and pre-achievement as the covariate. Each hypothesis has a different independent known as the categorical variable when using ANCOVA statistics. The three categorical variables are (a) instruction type, (b) gender, and (c) ethnicity. The purpose of the research is to evaluate two groups of students in order to determine any difference between student achievements with CAI versus TDI. Each group will be given the same lessons that includes six units in a physical science class; three units with a traditional laboratory experience, and three units using virtual labs and simulations. The reason the research is significant is to study the impact of laboratory simulations on student achievement.

The research study will begin during student registration. Students who register for the class will be invited to participate in the research study. The students that join the research study will compose the population for the study. Numbers will be assigned to the students for the research study so their privacy will be protected. CRCT scores will be collected at this time to establish pre-achievement values. Before each unit during the physical science class the students will be given a benchmark test to assess their prior knowledge. After two weeks, the students will repeat the same test again as a post test. The academic gain/loss in achievement will be recorded for every test. The same protocol will be used five more times (equaling the number

necessary so the achievement is measured for the six units offered during the class). At the conclusion of the class, three units will be tested that used the traditional lab instruction and three units that used the virtual lab simulations will be tested separately. The same students are part of the research treatment and control groups. Results will be evaluated and reported.

## Analyzing the Data

### Research Question 1

The first research question sought to assess whether there is a difference in the students' achievements in science due to the different laboratory instruction type (virtual simulation or traditional lab instruction) after controlling for pre-achievement test scores.

The mean score for the students who received traditional lab instruction was 54.77 with a standard deviation of 10.05 while that of the students who received supplemental CAI simulations (virtual) and labs was 57.78 with a standard deviation of 10.17 (see table 1).

**Descriptive Statistics**

Dependent Variable: Achievement

| Instruction type | Mean | Std. Deviation | N |
|---|---|---|---|
| Traditional | 54.773333 | 10.0509902 | 50 |
| Virtual | 57.780000 | 10.1690050 | 50 |
| Total | 56.276667 | 10.1718185 | 100 |

**Table 1**

ANCOVA assumes equality of variance. The assumption was tested using the Levene's Test of Equality of Error Variances. P-value = .504 > .05 (see table 2). We fail to reject the null hypothesis. Therefore, the assumption is met and the use of ANCOVA is validated.

**Levene's Test of Equality of Error Variances[a]**

Dependent Variable: Achievement

| F | df1 | df2 | Sig. |
|---|---|---|---|
| .451 | 1 | 98 | .504 |

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Preachievement + Instructiontype

**Table 2**

The effect of instruction type is statistically insignificant at 5 percent, F= 3.431, p-value = 0.067 > 0.05. Therefore, there is statistically no significant difference between students who learn using virtual simulation compared to those who learn using traditional lab instructions when we control for pre-achievement. Therefore, we can conclude that virtual simulation instructional type for sciences delivers the same results as a traditional lab instruction when we use achievement as a yardstick for student academic progress. The effect size is 0.034 (see table 3). Only 3.4 percent of the variation in achievement is explained by the different instruction type.

The effect of pre-achievement is statistically significant at 5 percent, F= 10.018, p-value = 0.002 < 0.05. The effect size of pre-achievement is 0.094. Therefore, pre-achievement explains 9.4 percent of the variations in the achievement.

**Tests of Between-Subjects Effects**

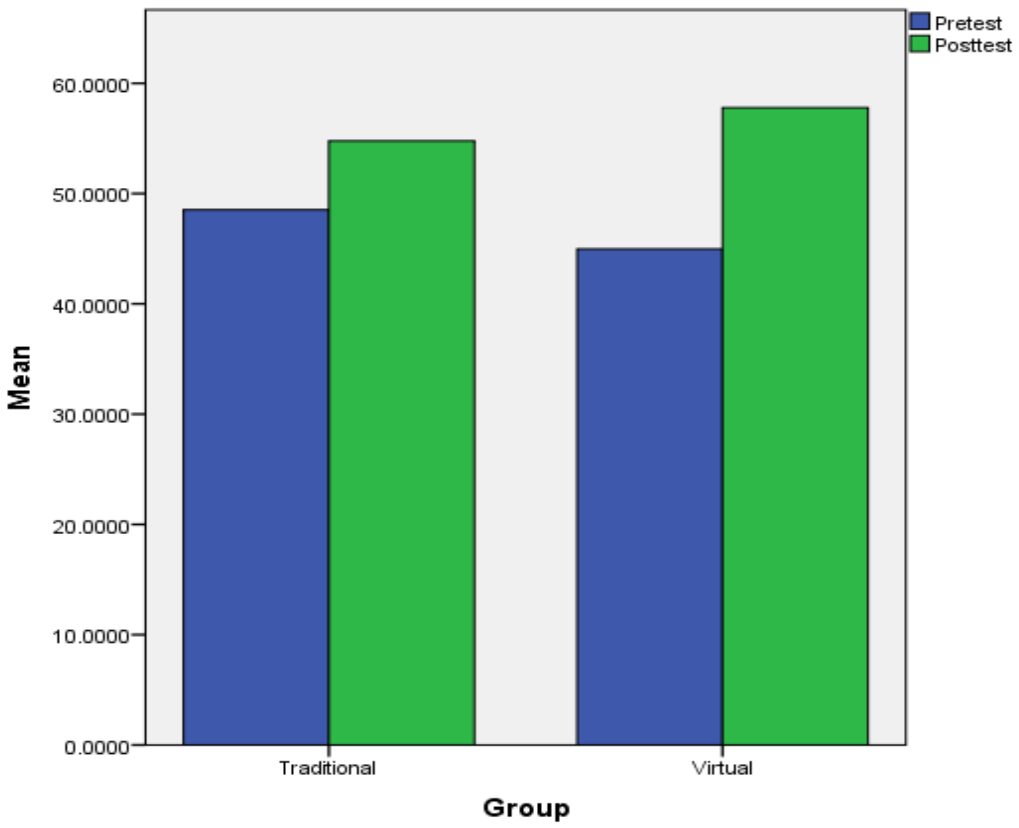
Dependent Variable: Achievement

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared | Noncent. Parameter | Observed Power[b] |
|---|---|---|---|---|---|---|---|---|
| Corrected Model | 1163.694[a] | 2 | 581.847 | 6.216 | .003 | .114 | 12.432 | .885 |
| Intercept | 30998.955 | 1 | 30998.955 | 331.177 | .000 | .773 | 331.177 | 1.000 |
| Preachievement | 937.693 | 1 | 937.693 | 10.018 | .002 | .094 | 10.018 | .880 |
| Instructiontype | 321.128 | 1 | 321.128 | 3.431 | .067 | .034 | 3.431 | .450 |
| Error | 9079.429 | 97 | 93.602 | | | | | |
| Total | 326949.444 | 100 | | | | | | |
| Corrected Total | 10243.123 | 99 | | | | | | |

a. R Squared = .114 (Adjusted R Squared = .095)

b. Computed using alpha = .05

**Table 3**




**Research Question 2**

The second research question sought to assess whether there is a difference in the students' achievements in science due to the different instruction type (virtual simulation and traditional lab instruction) after controlling for pre-achievement test scores and gender (male or female).

There were 28 male students and 22 female students. The mean score for the male students who received traditional lab instruction was 50.98 with a standard deviation of 8.63 while that of female students was 59.59 with a standard deviation of 9.82. On the other hand, the mean score for the male students who received supplemental virtual simulation instruction was

59.51 with a standard deviation of 9.30 while that of female students was 55.57 with a standard deviation of 10.99 (see table 4).

**Descriptive Statistics**

Dependent Variable: Achievement

| Instructiontype | Gender | Mean | Std. Deviation | N |
|---|---|---|---|---|
| Traditional | Male | 50.988095 | 8.6355005 | 28 |
| | Female | 59.590909 | 9.8194989 | 22 |
| | Total | 54.773333 | 10.0509902 | 50 |
| Virtual | Male | 59.511905 | 9.3026312 | 28 |
| | Female | 55.575758 | 10.9969605 | 22 |
| | Total | 57.780000 | 10.1690050 | 50 |
| Total | Male | 55.250000 | 9.8785044 | 56 |
| | Female | 57.583333 | 10.5011689 | 44 |
| | Total | 56.276667 | 10.1718185 | 100 |

**Table 4**

The assumption of equality of variance was tested using the Levene's Test of Equality of Error Variances. P-value = .610 > .05 (see table 5). We fail to reject the null hypothesis. Therefore, the assumption is met and the use of ANCOVA is validated.

**Levene's Test of Equality of Error Variances[a]**

Dependent Variable: Achievement

| F | df1 | df2 | Sig. |
|---|---|---|---|
| .610 | 3 | 96 | .610 |

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Preachievement + Instructiontype + Gender + Instructiontype * Gender

**Table 5**

The effect of the interaction between gender and instruction type is statistically significant at 5 percent, F= 9.120, p-value = 0.003 < 0.05. The effect size of the interaction between instruction type and gender is 0.088. Therefore, it explains 8.8 percent of the variations in the achievement. Male students have a higher mean score when they learn using virtual simulation compared to when they learn using traditional lab instructions. Therefore, we can conclude that male students perform better in virtual simulation environments compared to a traditional lab environment.

The effect of instruction type is statistically insignificant at 10 percent, F= 2.303, p-value = 0.132 > 0.1 when we control for gender and pre-achievement. Therefore, there is no statistically significant difference between students who learn using virtual simulation compared to those who learn using traditional lab instructions when we control for both pre-achievement and gender. Therefore, we can conclude there is no instruction type that is superior to the other when we control for both gender and pre-achievement. The effect size is 0.024 (see table 3). Only 2.4 percent of the variation in achievement is explained by the different instruction type.

The effect of pre-achievement is statistically significant at 1 percent, F= 10.018, p-value = 0.004 < 0.01. The effect size of pre-achievement is 0.082. Therefore, pre-achievement explains 8.2 percent of the variations in the achievement.

The effect of gender is statistically insignificant 10 percent, F = 1.336, p-value = 0.251 > 0.1.

**Tests of Between-Subjects Effects**

Dependent Variable: Achievement

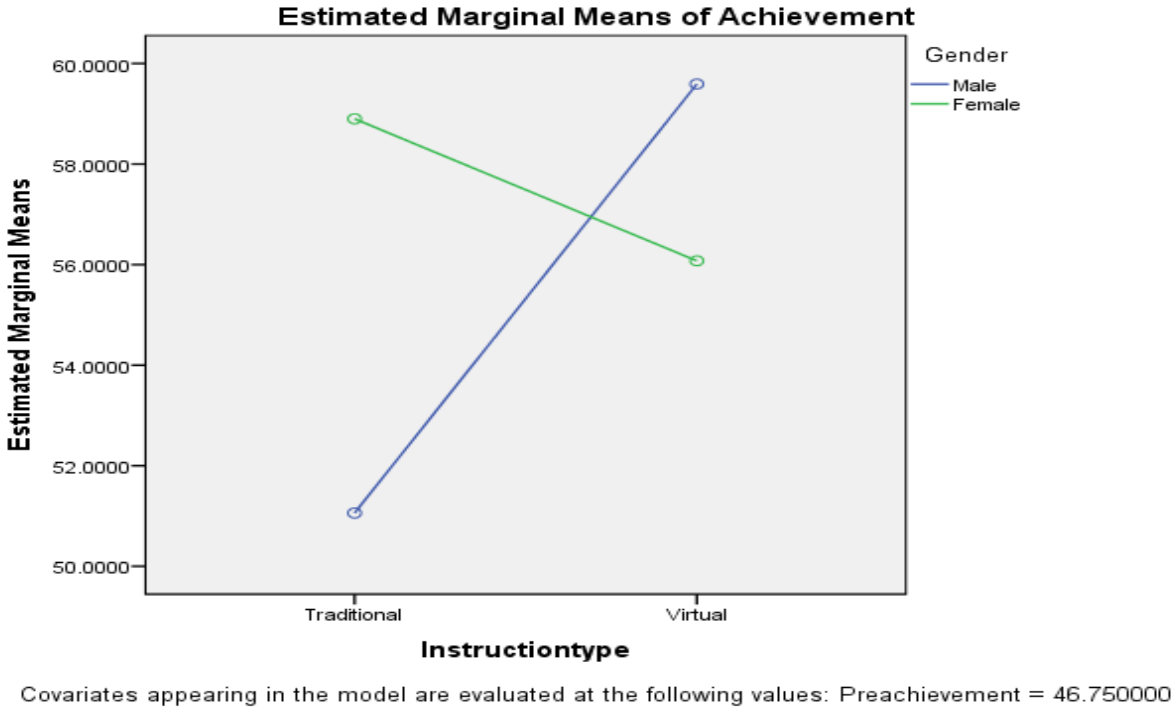
| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared | Noncent. Parameter | Observed Power[b] |
|---|---|---|---|---|---|---|---|---|
| Corrected Model | 2062.046[a] | 4 | 515.511 | 5.986 | .000 | .201 | 23.945 | .981 |
| Intercept | 31788.408 | 1 | 31788.408 | 369.132 | .000 | .795 | 369.132 | 1.000 |
| Preachievement | 733.384 | 1 | 733.384 | 8.516 | .004 | .082 | 8.516 | .823 |
| Instructiontype | 198.308 | 1 | 198.308 | 2.303 | .132 | .024 | 2.303 | .324 |
| Gender | 115.013 | 1 | 115.013 | 1.336 | .251 | .014 | 1.336 | .208 |
| Instructiontype * Gender | 785.365 | 1 | 785.365 | 9.120 | .003 | .088 | 9.120 | .848 |
| Error | 8181.077 | 95 | 86.117 | | | | | |
| Total | 326949.444 | 100 | | | | | | |
| Corrected Total | 10243.123 | 99 | | | | | | |

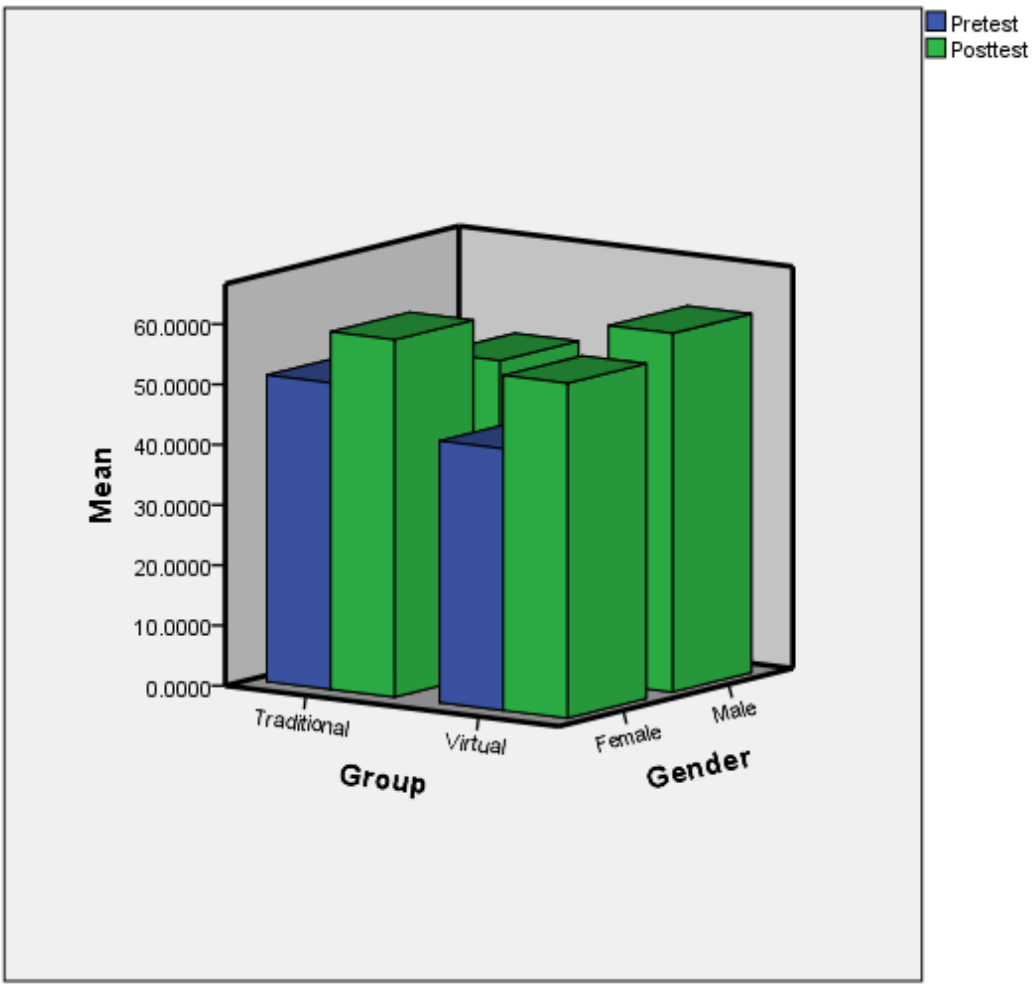
a. R Squared = .201 (Adjusted R Squared = .168)

b. Computed using alpha = .05

**Table 6**

A graph of the of the estimated margins of achievement shows that there is an interaction between the two variables (see Figure 1)






**Research Question 3**

The third research question sought to assess whether there is a difference in the students' achievements in science due to the different instruction type (virtual simulation and traditional lab instruction) after controlling for pre-achievement test scores and ethnicity.

Table 7 below provides a summary of the mean achievement for both types of instructions mode according to the ethnicity.

**Descriptive Statistics**

Dependent Variable: Achievement

| Instructiontype | Ethnicity | Mean | Std. Deviation | N |
|---|---|---|---|---|
| Traditional | Asian | 59.000000 | . | 1 |
| | Black | 53.788618 | 9.5124936 | 41 |
| | Hispanic | 60.333333 | 11.7236703 | 3 |
| | White | 58.666667 | 14.4010031 | 5 |
| | Total | 54.773333 | 10.0509902 | 50 |
| Virtual | Asian | 43.000000 | . | 1 |
| | Black | 58.739837 | 9.6831791 | 41 |
| | Hispanic | 58.222222 | 11.8571747 | 3 |
| | White | 52.600000 | 12.6916420 | 5 |
| | Total | 57.780000 | 10.1690050 | 50 |
| Total | Asian | 51.000000 | 11.3137085 | 2 |
| | Black | 56.264228 | 9.8586356 | 82 |
| | Hispanic | 59.277778 | 10.6090458 | 6 |
| | White | 55.633333 | 13.1903912 | 10 |
| | Total | 56.276667 | 10.1718185 | 100 |

**Table 7**

The assumption of equality of variance was tested using the Levene's Test of Equality of Error Variances. P-value = .509 > .05 (see table 8). We fail to reject the null hypothesis. Therefore, the assumption is met and the use of ANCOVA is validated.

**Levene's Test of Equality of Error Variances[a]**

Dependent Variable: Achievement

| F | df1 | df2 | Sig. |
|---|---|---|---|
| .902 | 7 | 92 | .509 |

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Preachievement + Instructiontype + Ethnicity + Instructiontype * Ethnicity

**Table 8**

**Tests of Between-Subjects Effects**

Dependent Variable: Achievement

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared | Noncent. Parameter | Observed Power[b] |
|---|---|---|---|---|---|---|---|---|
| Corrected Model | 2172.296[a] | 8 | 271.537 | 3.062 | .004 | .212 | 24.493 | .948 |
| Intercept | 10194.700 | 1 | 10194.700 | 114.947 | .000 | .558 | 114.947 | 1.000 |
| Preachievement | 1329.173 | 1 | 1329.173 | 14.987 | .000 | .141 | 14.987 | .969 |
| Instructiontype | 225.264 | 1 | 225.264 | 2.540 | .114 | .027 | 2.540 | .351 |
| Ethnicity | 195.540 | 3 | 65.180 | .735 | .534 | .024 | 2.205 | .201 |
| Instructiontype * Ethnicity | 872.465 | 3 | 290.822 | 3.279 | .025 | .098 | 9.837 | .733 |
| Error | 8070.827 | 91 | 88.690 | | | | | |
| Total | 326949.444 | 100 | | | | | | |
| Corrected Total | 10243.123 | 99 | | | | | | |

a. R Squared = .212 (Adjusted R Squared = .143)

b. Computed using alpha = .05

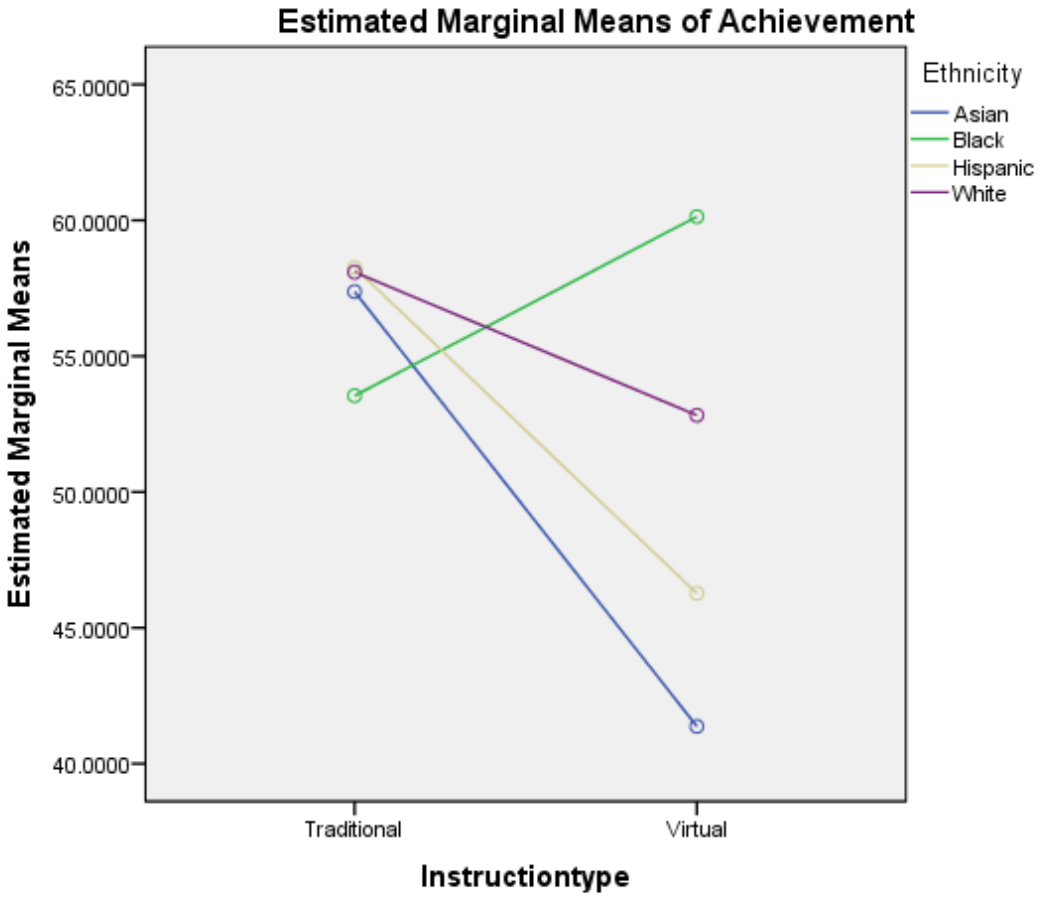
The effect of the interaction between ethnicity and instruction type is statistically significant at 5 percent, F= 3.279, p-value = 0.024 < 0.05. The effect size of the interaction between instruction type and ethnicity is 0.098. Therefore, it explains 9.8 percent of the variations in the achievement. Hispanic students perform best in a traditional lab environment while Black students perform best in a virtual learning environment.

The effect of instruction type is statistically insignificant at 10 percent, F= 2.540, p-value = 0.114 > 0.1 when we control for ethnicity and pre-achievement. Therefore, there is no statistically significant difference between students who learn using virtual simulation compared to those who learn using traditional lab instructions when we control for both pre-achievement and ethnicity. Therefore, we can conclude there is no instruction type that is superior to the other when we control for both ethnicity and pre-achievement. The effect size is 0.027 (see table 3). Only 2.7 percent of the variation in achievement is explained by the different instruction types.

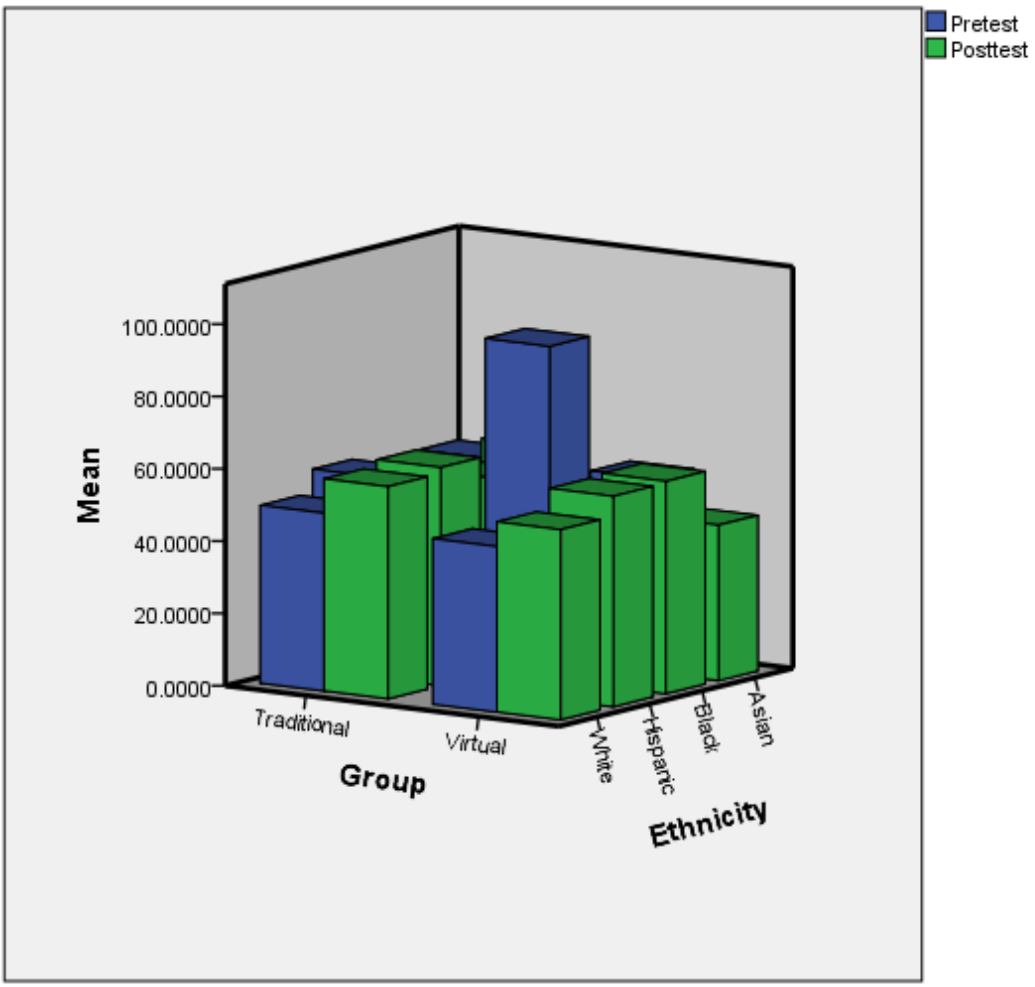
The effect of pre-achievement is statistically significant at 1 percent, F= 14.987, p-value = 0.000 < 0.01. The effect size of pre-achievement is 0.141. Therefore, pre-achievement explains 14.1 percent of the variations in the achievement.

The effect of ethnicity is statistically insignificant 10 percent, F = 0.735, p-value = 0.024 > 0.1.

A graph of the of the estimated margins of achievement shows that there is an interaction between the two variables (see Figure 1)




Covariates appearing in the model are evaluated at the following values: Preachievement = 46.750000




**Conclusion and Implication**

This study sought to assess whether there is a difference in the students' achievements in science due to the different instruction type (virtual simulation and traditional lab instruction) using ANCOVA. Firstly, we controlled for pre-achievement score only. Secondly, we controlled for pre-achievement score and gender. Thirdly, we controlled for pre-achievement and ethnicity. The study reveals that there is no statistically significant difference between students who learn using virtual simulation compared to those who learn using traditional lab instructions in the

three scenarios. Similarly, there are no statistically significant differences explained by gender and ethnicity.

However, when we consider the interaction between instruction type and gender, there are statistically significant differences. The interaction explains at least 8.8 percent of the differences in the mean scores observed. Male students tend to perform better in a virtual simulation learning environment compared to a traditional lab instruction environment whereas female students perform better in a traditional lab environment compared to a virtual simulation learning environment.

Similarly, when we consider the interaction between instruction type and ethnicity, there are statistically significant differences. The interaction explains at least 9.8 percent of the differences in the mean scores observed. Hispanics perform best in a traditional lab environment while Blacks perform best in a virtual learning environment.

# Chapter V

## Implications, Applications, Limitations and Validity

### Summary

The scope and sequence of physical science includes laboratories as important aspects that ensure that students achieve better achievement outcomes, and enable them to gather experience using physical concepts. Educators worldwide, as published within the literature review, agree with the importance attached to the laboratory setting, but differences occur in the application of different instructional strategies. This research analyzed and compared the applicability of both virtual labs and traditional labs to the learning of physical science concepts. The researcher analyzed whether there were any discernable differences in the performances of the students subjected to either virtual simulations or those subjected to traditional lab instructions. The data gathered in this research, leads the researcher to insights regarding the learning approaches in the physical science classroom. Both approaches have the goal of ensuring that students increase their interest and abilities in physical science. (Tüysüz, 2010).

Instructional techniques that employ both laboratory practicums were the major subject of this study. The researcher first recognized that with the technological advancements in the modern day era, traditional instruction methodologies have been challenged. Based on this research, however, it is clear the time for phasing out traditional lab instruction in favor of virtual simulation has not yet come. Despite the literature that suggests the positive impact virtual simulation has, traditional lab instruction have the same achievement outcomes. In this setting it

is clear that the application of virtual simulation does not significantly alter academic performance in physical science, meaning that education stakeholders still need to work on optimizing the virtual reality concepts in the lab settings, while still employing traditional instructional techniques. Educational stakeholders need to be more prudent when applying changes in instructional methodologies in education. Assumptions should not be made that any form of new methodologies results in positive outcomes for the learners.

**Analysis of findings**

The lack of a statistically significant difference between the students subjected to traditional lab instructions and those subjected to virtual simulation causes the researcher to question the real position or role of virtual simulation. To this end, stakeholders in the physical science education sector need to consider the virtual simulation techniques as being complementary to the traditional lab instruction methodologies. The two need to be viewed as working towards the realization of a common goal as opposed to being viewed as competing with each other. Policy makers in physical science education, therefore, need to understand the strong points of each of the instructional methodologies. After identifying the strong points, efforts can be made to look into how the two approaches to instructions can be brought together to ensure better educational outcomes for the students. In most cases, virtual labs are used to overcome the challenges that are experienced in traditional lab settings. (Lewis, 2014). Through this perspective, a complementary relationship is seen between the two. The results of the research were analyzed, and the researcher showed that neither virtual simulation nor traditional lab instructions led to significant differences in student outcomes. Stakeholders, therefore, need to view the two as counterparts with the potential of improving the educational outcomes for physical science students. Stakeholders in education therefore need to look into how different

instructional methodologies can be brought together with the common goal of improving the learners' performances.

**Gender**

The interpretation of data also indicated that there were some significant differences in the outcomes of the application of virtual simulation due to gender. According to the study, male students scored better when the virtual simulation was applied compared to their female counterparts. In addition, the black students seemed to perform better under virtual instructions, compared to students of other ethnicities. To this end, therefore, there is the need to look into the faults that come with virtual labs. In an ideal educational setting, teachers need to employ instructional strategies that influence all the students equally irrespective of their gender or race. In the virtual simulation, however, the instructional technique seems to favor some of the learners, therefore pointing at some faults in its application. These findings lead the researcher to data that points to the existence of factors that impact differential academic achievements for students from different groups within the society, especially in regards to gender, social class and ethnicity. The implication for policy makers is to discover ways which virtual learning can result in uniform education outcomes for students from different social groupings. There is also a need to employ more intense research designs that could give details explaining the findings. This builds on the literature that suggests that experimental researchers need to apply designs that complement their research design in a bid to yield richer data (Odle & Mayer, 2009).

**Pre-achievement**

Pre-achievement was a central aspect of this study. The analysis of the data by the researcher indicated that there were no significant differences in the application of both virtual learning techniques and the application of traditional lab instructional strategies. An argument can, therefore, be made that for better outcomes to be realized through virtual labs, there is the need for the application of prior knowledge. In addition, it can be argued that complex instructional methodologies work well for students with higher levels of maturity, independent learners, in terms of both age and mental capabilities. To this end, therefore, policymakers need to examine measures of gauging the efficiency of virtual learning. Education stakeholders need to compute the need of prior knowledge in understanding the operations of virtual labs. For lower level learners, there is the possibility that a lack of maturity and prior knowledge, will challenge the efficiency of applying virtual learning techniques.

**Discussion of research findings**

The results of this research leads the researcher to re-think the role of laboratory sessions in learning physical science. In the conventional setting, laboratory experiments are used to improve the students' understanding of scientific concepts while improving the operational capability of handling equipment, following procedures and overall conduct in the experimental setting (Climent-Bellido et al, 2003). The basic understanding of virtual learning is that students get to observe computer-simulated scenarios, meaning that the hands-on experience in traditional lab settings is omitted. The analysis of data revealed that there were no significant positive learning outcomes because of applying virtual learning techniques, the question of whether students actually lose through the application of virtual simulations should arise. Physical science education policy makers, therefore, need to look into the possibility of virtual learning

resulting in the loss of insight learners get through the application of traditional lab instructional techniques

**Balancing positive outcomes and negative impacts**

From this study, it is apparent that education stakeholders need to find a balance between the positive outcomes of applying virtual simulation techniques and the possible negative impacts the techniques have on the learners of physical science. Advocates of the use of virtual labs point to the fact that these techniques give the chance for doing away with the challenges observed in traditional lab settings. According to Lewis (2010), experiments and the need to conduct them repeatedly is a financial challenge to most learning institutions. Chemicals used in chemical experiments, for instance, can be expensive, meaning that simulations come as a welcome remedy to the challenge of cost. (Climent-Bellido et al., 2003). With such positives in mind, however, there are the negative aspects that may come because of applying virtual simulations. A major concern is the loss of kinesthetic learning on the side of the students. In the traditional lab settings, students are allowed to manipulate apparatus and tools as they see fit. With simulations, however, the opportunity to manipulate anything is very limited. In the long run, there is the possibility of students overlying on simulations as the easier approach to scientific experimentation. This can lead to stifled creativity, which negatively influences the students' problem solving skills and the ability of learners to effectively participate in physical science. The emphasis should not be on the overall advantages that virtual simulation brings to the lab setting, while ignoring the possible negative implications to the quality of education the students receive.

**Building on the literature**

The researcher builds on the literature that seeks to look into the impacts of modernized instructional techniques as applied to physical science. With the study having established no significant differences in performance for students subjected to either virtual simulation or traditional lab instructions, the question on the efficiency of new instructional techniques is raised. There are many conclusions from this study for education as a whole, with the primary concern being whether virtual learning is worth applying in the education sector. In physical science, there is the need for stakeholders to look into how virtual reality techniques can be used in collaboration with traditional lab instructional techniques to yield better learning outcomes for the students (Tüysüz, 2010). Stakeholders, therefore, need to find a balance of the positive and negative aspects arising from the application of virtual learning techniques.

**Limitations of the research**

In this study, the researcher sought to employ the experimental research design. To this end, the study was conducted in adherence to two important criteria. The first criterion was the identification of the experimental control. To this end, the study had some subjects who were treated differently with the goal of testing the independent variable. The second criterion was the observation of specific measure. Here, the researcher used 47 subjects, who were manipulated to test the research hypothesis. For many researchers, the use of experimental research is the most appropriate technique, especially when making inferences regarding the different instructional techniques used in educational settings (Odle & Mayer, 2009). The argument is that the use of trials is the best way through which education stakeholders can get to learn more regarding factors affecting educational outcomes, especially ones tied to types of instructional techniques. In general, experimental research, when properly done has the potential of allowing for the

drawing of conclusions and the conceptualization of various causal relationships. There are, however, various limitations when the design is applied especially in educational research. Such limitations were experienced in this research.

The first limitation of this research was regarding the method. To this end, the criteria required for effective application of experimental research runs the risk of making the study artificial. This is because criteria such as experimental controls, applying appropriate measures and random subject assignment have a sense of artificiality. When conducting educational research in a school setting, you have to abide by the schools' protocol and it is preferable for the settings of the study to be as natural as possible. The implication is that there is a possibility of the insight gained from the research not being a true representation of the situation on the ground. In addition, there was a limitation in regards to achieving perfectly controlled conditions. This was because the research was conducted in a school setting where controlling of all conditions proved to be difficult. There was, therefore, the limitation of trying to adhere to the requirements of experimental research and trying to maintain the practicality of the research and its findings. The other limitation came in the form of theory. In the experimental research design, a researcher is able to pinpoint the relationships between various variables, but finds it challenging to give details on the causal relationships between the variables (Schanzenbach, 2012). To this end, the researcher sought to compare the outcomes of applying both virtual simulation and traditional lab instructional techniques. Despite the fact that the research established that the two instructional strategies did not result in significant differences in the learning outcomes for the students, the research design was unable to give reasons behind these findings.

Another limitation of this research was the aspect of unseen defects within the subjects. In a conventional research setting, a researcher seeks to have subjects who have uniform characteristics in terms of age, heath status and gender (Schanzenbach, 2012). To this end, this researcher sought to use subjects who were within the same level of learning, and who were of relatively the same age. The limitation of subjects' defects arises from the fact that there is the possibility of certain unforeseen differences within the subjects used in the research. When the subjects have unforeseen defects, there is a possibility of the defects leading to skewed data. The subjects, in this case, may have had differences in regards to their genetic wiring, which has the potential of influencing findings. Such unseen differences and defects may have influenced the findings of the research in one way or the other

The research also had a confounder limitation. Confounder limitations refer to factors with the ability to affect the results of a study, but limitations that are not considered by the researcher (Schanzenbach, 2012). To this end, one possible confounder was the aspect of maturity, especially in regards to the use of virtual simulation techniques. After the study was complete, the researcher established that the effective use of virtual learning programs was more effective for mature users as opposed to younger users. Given the fact that the maturity variable was not considered during the research, it may have affected the findings. In addition, the fact that the aspect of maturity cannot be effectively measured makes this confounder a real threat to the findings of the research. The study also had the limitation of time used and the timings applied. Due to other constraints facing the researcher, the study was conducted within a limited period. The aspect of time as a limitation to experimental research occurs where the effectiveness of a program is measured soon after its introduction (Odle & Mayer, 2009). To this end, the application of virtual simulation cannot be regarded as an entirely new concept in the laboratory

settings, but it can be agreed that the virtual learning concept is still in its infancy stages especially in physical sciences. To this end, there is a possibility that as the virtual learning concepts are continuously rolled out, better outcomes are realized. To this end, therefore, the results of this study may be a faulty representation of the situation in the future. The possibility of the situation changing in the long run reduces the viability of this study. It would have been preferable for the study to take a more longitudinal approach, where the subjects were observed over a long period of time. Time, therefore, was a major limitation to this research.

The study also faced the question of its external validity. In educational research, researchers are often faced with the question of whether the results of a study can be replicated in a different location or when a different set of subjects is used (Schanzenbach, 2012). This is always a challenge to researcher since, in the ideal situation, the findings of a study need to be universally applicable. There is, however, the chance of the findings not being replicated elsewhere. In this particular study, the researcher used a small number of subjects from a single setting. The failure to conduct the research on a wider setting, therefore, poses a challenge to the external validity of the findings of this research. The insight gained from the study may only be applicable to locations and settings with the identical characteristics of the study area. Given that, that proposition is highly unlikely, the findings may not be applicable to a larger population.

Another possible limitation to this study was the Hawthorne Effect. This effect refers to the possibility of the subjects involved in a study changing their mannerisms as a result of acknowledging that they are being watched (Odle & Mayer, 2009). It is natural for a person to change their behavior once they identify that their actions are being watched or measured. The subjects of an experiment may, therefore, deviate from their normal patterns of behavior, making the research findings to be an untrue reflection of the normal subject behavior. In this study, the

main question being measured was the achievement of the learners because of the application of either virtual simulation or traditional lab instructional techniques. If the subjects were aware that their performances were being observed, the Hawthorne Effect may have come into play, where they altered their behavior. This may have resulted in the realization of performances higher than normal, or performances lower than normal. To this end, the real relationships between the variable may be different when the subjects know they are not being watched or their performance is being measured.

Another major limitation came in the form of costs. Experimental research designs are usually an expensive venture that requires a heavy financial input to effectively carry out all the research activities (Schanzenbach, 2012). The cost limitation may, therefore, result in the realization of results that are not a true representation of the study. This is because the researcher is constrained and is not able to gather the required or sufficient data. In this case, the researcher faced the cost constraint given the fact that the study was self-sponsored. To this end, there was the limitation of the level of manipulation of the subjects and variable, which would have otherwise led to richer data. The limits in budget meant that the researcher used a small sample, and did not enlist the services of experts in various stages of the research. To this end, there is the possibility of the study having more errors, which would have been dealt with through better funding of the research.

**Implications**

The findings of this study have a variety of impacts to future research. Scholars in different fields of science education agree with the proposition that the laboratory plays an important role in improving the learning outcomes for science students (Tüysüz, 2010). To this end, most researchers have looked into the problems that face traditional laboratory settings.

Such problems include the expensive nature of laboratory equipment, the time required for planning, the difficulties in measuring student performances and the difficulty in coming up with perfect lab conditions for conducting experiments. Research needs to be conducted to provide insight on the best instructional techniques that apply to different ethnicities. With this study having established that virtual simulation is equally effective as traditional laboratory instructional techniques, further research needs to be conducted on aspects that affect efficiency in virtual labs.

**Recommendations**

Further research building on this study, therefore, needs to take into consideration the impact of the students' maturity cofounder. Changes are, therefore necessary when applying virtual reality techniques in the classroom, to avoid a situation where less-competent students are graduated as a result of poor instructional methodologies. This should be done with the goal of coming up with solutions to the problems associated with virtual learning and ensuring that learners get the best out of these settings.

Further research also needs to be conducted with the goal of conceptualizing the real benefits of the use of virtual reality techniques in the laboratory. Given the technological age we live in; technological advancements are occurring in virtually all the facets of life. Researchers in physical science education need to look into the nature of problems that face different laboratory settings. Instructional techniques, especially in physical sciences, cannot risk being left behind, necessitating further research on the exact benefits of the concept of virtual reality in laboratory settings. To this end, virtual simulation has been identified to help in overcoming the myriad of problems experienced in the traditional labs such as problems with space, finances, planning, and safety. Researchers should, however, look into the benefits from the learners' perspective, with

the goal of conceptualizing how learners stand to benefit from the use of virtual reality in laboratory settings.

Further research also needs to be conducted on how simulations can be better structured to meet the goals of experiments, especially in physical science. The researcher realized that there were no significant differences in the performances of students subjected to either virtual simulations or traditional lab instructional techniques. Therefore, the application of virtual reality techniques may be resulting in the failure of students to develop the skills that come with laboratory work. Virtual learning possibly stifles skills such as creativity. Research, therefore, needs to be conducted to establish whether such arguments are valid. In addition, researchers need to be conducted on how virtual learning environments in physical science learning can be designed to meet all the needs of the students. Such research will go a long way in informing policy makers on how virtual learning can be optimized to help students gain skills and expertise in physical science.

This researcher realized that gender is an important aspect to consider when gauging the effectiveness of different instructional techniques. The researcher established that there was a difference in the academic outcomes of male learners and their female counterparts when the virtual simulation was applied in a laboratory setting. The data indicated that male learners seemed to perform better when they were subjected to virtual simulations. The female learners posted lower performances, suggesting that virtual reality learning did not positively affect the female learners. Researchers need to look into this scenario in detail, with the goal of realizing the factors that underlie the poor performance of female learners once virtual learning is introduced. If published, these results should inform policy makers on how a level academic

platform for both male and female learners can be realized especially once a technology is used in instructional pedagogy.

Another area of research that should be emphasized is the change ethnicity brings to the effectiveness of different instructional techniques. This researcher revealed there was a significant difference in the outcomes of the students who were subjected to different instructional techniques. According to the findings, Hispanics performed better when subjected to traditional instructional techniques, while African-Americans posted better results when virtual simulations were introduced. It would be a mistake to assume that all types of instructional techniques affect all the learners uniformly. Obtaining this knowledge will enable stakeholders to bridge the gap in the educational outcomes for students from different ethnic backgrounds. In addition, such insight will be instrumental in showing how different instructional techniques can be optimized to meet the needs of students from different ethnicities. This will help in ensuring that the educational offerings for all students are leveled, with the goal of realizing greater academic achievement.

**Concluding thoughts**

This researcher, having established the absence of significant differences in the performance of learners subjected to different instructional lab techniques points at a need to research on how the two approaches can be brought together. The researcher established that virtual simulation and traditional lab instructions both have strong points that are beneficial to the science learners. Further research, therefore, needs to be conducted on how the two approaches can be brought together into a complementary relationship. Some researchers have focused on examining the individual benefits of the two approaches, with literature lacking on

the benefits of applying the two methodologies jointly. There is, therefore, a gap of knowledge regarding the application of multiple instructional techniques in a single setting.

## Implications, Applications, Limitations and Validity

The scope and sequence of physical science reveals laboratories as important aspects that ensure that students achieve better achievement outcomes, and enable them to gather experience using physical concepts. The scholarly world, therefore, agrees with the importance attached to the laboratory setting, but differences occur in the application of different instructional strategies. This research analyzed and compared the applicability of both virtual labs and traditional labs to the learning of physical science concepts. The researcher analyzed whether there were any discernable differences in the performances of the students subjected to either virtual simulations or those subjected to traditional lab instructions. The data gathered in this research, leads to insights regarding the learning approaches in the physical science classroom. Both approaches have the goal of ensuring that students increase their interest and abilities in physical science. (Tüysüz, 2010).

Instructional techniques that employ both laboratory practicums were the major subject of this study. The research first recognized that with the technological advancements in the modern day era, traditional instruction methodologies have been challenged. Based on this research, however, it is clear the time for phasing out traditional lab instruction in favor of virtual simulation has not yet come. Despite the literature that suggests the positive impact virtual simulation has, traditional lab instruction still yields the same achievement outcomes. In this setting it is clear that the application of virtual simulation does not significantly alter academic performance in physical science, meaning that education stakeholders still need to work on optimizing the virtual reality concepts in the lab settings, while still employing traditional

instructional techniques. The implication here is that educational stakeholders need to be more prudent when applying changes in instructional methodologies in education. Assumptions should not be made that any form of new methodologies results in positive outcomes for the learners.

The lack of a statistically significant difference between the students subjected to traditional lab instructions and those subjected to virtual simulation begs to question the real position or role of virtual simulation. To this end, stakeholders in the physical science education sector need to consider the virtual simulation techniques as being complementary to the traditional lab instruction methodologies. The two need to be viewed as working towards the realization of a common goal as opposed to being viewed as competing with each other. Policy makers in physical science education, therefore, need to understand the strong points of each of the instructional methodologies. After identifying the strong points, efforts can be made to look into how the two approaches to instructions can be brought together to ensure better educational outcomes for the students. In most cases, virtual labs are used to overcome the challenges that are experienced in traditional lab settings. (Lewis, 2014). Through this perspective, a complementary relationship is seen between the two. The results of the research indicated that neither virtual simulation nor traditional lab instructions led to significant differences in student outcomes. Stakeholders, therefore, need to view the two as counterparts with the potential of improving the educational outcomes for physical science students. Stakeholders in education therefore need to look into how different instructional methodologies can be brought together with the common goal of improving the learners' performances.

**Gender**

The results of the research also indicated that there were some significant differences in the outcomes of the application of virtual simulation due to gender. According to the study, male

students posted better performances when the virtual simulation was applied compared to their female counterparts. In addition, the black students seemed to perform better under virtual instructions, compared to students of other ethnicities. To this end, therefore, there is the need to look into the faults that come with virtual labs. In an ideal educational setting, teachers need to employ instructional strategies that influence all the students equally irrespective of their gender or race. In the virtual simulation, however, the instructional technique seems to favor some of the learners, therefore pointing at some faults in its application. Such findings build on to the data that points at the existence of factors that impact differential academic achievements for students from different groups within the society, especially in regards to gender, social class and ethnicity. The implication for policy makers is to come up with ways to which virtual learning can result in uniform education outcomes for students from different social groupings.

**Pre-achievement**

Pre-achievement was a central aspect of this study. The results of the study indicated that there were no significant differences in the application of both virtual learning techniques and the application of traditional lab instructional strategies. An argument can, therefore, be made that for better outcomes to be realized through virtual labs, there is the need for the application of prior knowledge. In addition, it can be argued that complex instructional methodologies work well for students with higher levels of maturity, independent learners, in terms of both age and mental capabilities. To this end, therefore, policymakers need to come up with definite measures of gauging the efficiency of virtual learning. Education stakeholders need to compute the need of prior knowledge in understanding the operations of virtual labs. For lower level learners, there is the possibility that a lack of maturity and prior knowledge, will challenge the efficiency of applying virtual learning techniques.

The results of this research also necessitate the re-thinking of the role of laboratory sessions in learning physical science. In the conventional setting, laboratory experiments are used to improve the students' understanding of scientific concepts while improving the operational capability of handling equipment, following procedures and overall conduct in the experimental setting (Climent-Bellido et al., 2003). The basic understanding of virtual learning is that students get to observe computer-simulated scenarios, meaning that the hands-on experience in traditional lab settings is omitted. With the research showing that there were no significant positive learning outcomes because of applying virtual learning techniques, the question of whether students actually lose through the application of virtual simulations should arise. Physical science education policy makers, therefore, need to look into the possibility of virtual learning resulting in the loss of insight learners get through the application of traditional lab instructional techniques. Changes are, therefore necessary when applying virtual reality techniques in the classroom, to avoid a situation where less-competent students are graduated as a result of poor instructional methodologies.

**Balancing positive outcomes and negative impacts**

From this study, it is apparent that education stakeholders need to find a balance between the positive outcomes of applying virtual simulation techniques and the possible negative impacts the techniques have on the learners of physical science. Advocates of the use of virtual labs point to the fact that these techniques give the chance for doing away with the challenges observed in traditional lab settings. According to Lewis (2010), experiments and the need to conduct them repeatedly is a financial challenge to most learning institutions. Chemicals used in chemical experiments, for instance, can be expensive, meaning that simulations come as a welcome remedy to the challenge of cost. (Climent-Bellido et al., 2003). With such positives in

mind, however, there are the negative aspects that may come because of applying virtual simulations. A major concern is the loss of kinesthetic learning on the side of the students. In the traditional lab settings, students are allowed to manipulate apparatus and tools as they see fit. With simulations, however, the opportunity to manipulate anything is very limited. In the long run, there is the possibility of students overlying on simulations as the easier approach to scientific experimentation. This can lead to stifled creativity, which negatively influences the students' problem solving skills and the ability of learners to effectively participate in physical science. Stakeholders, therefore, need to find a balance of the positive and negative aspects arising from the application of virtual learning techniques. The emphasis should not be on the overall advantages that virtual simulation brings to the lab setting, while ignoring the possible negative implications to the quality of education the students receive.

**Building on the literature**

This research builds on the literature that seeks to look into the impacts of modernized instructional techniques as applied to physical science. With the study having established no significant differences in performance for students subjected to either virtual simulation or traditional lab instructions, the question on the efficiency of new instructional techniques is raised. There are many implications of this study to education as a whole, with the primary concern being whether virtual learning is worth applying in the education sector. In physical science, there is the need for stakeholders to look into how virtual reality techniques can be used in collaboration with traditional lab instructional techniques to yield better learning outcomes for the students (Tüysüz, 2010).

**Limitations of the research**

In this study, the researcher sought to employ the experimental research design. To this end, the study was conducted in adherence to two important criteria. The first criterion was the identification of the experimental control. To this end, the study had some subjects who were treated differently with the goal of testing the independent variable. The second criterion was the observation of specific measure. Here, the researcher used 47 subjects, who were manipulated to test the research hypothesis. For many researchers, the use of experimental research is the most appropriate technique, especially when making inferences regarding the different instructional techniques used in educational settings (Odle & Mayer, 2009). The argument is that the use of trials is the best way through which education stakeholders can get to learn more regarding factors affecting educational outcomes, especially ones tied to types of instructional techniques. Experimental research, when properly done has the potential of allowing for the drawing of conclusions and the conceptualization of various causal relationships. There are, however, various limitations when the design is applied especially in educational research. Such limitations were experienced in this research.

The first limitation of this research was regarding the method. To this end, the criteria required for effective application of experimental research runs the risk of making the study artificial. This is because criteria such as experimental controls, applying appropriate measures and random subject assignment have a sense of artificiality. When conducting educational research, it is preferable for the settings of the study to be as natural as possible. The implication is that there is a possibility of the insight gained from the research not being a true representation of the situation on the ground. In addition, there was a limitation in regards to achieving perfectly controlled conditions. This was because the research was conducted in a school setting where

controlling of all conditions proved to be difficult. There was, therefore, the limitation of trying to adhere to the requirements of experimental research and trying to maintain the practicality of the research and its findings. The other limitation came in the form of theory. In the experimental research design, a researcher is able to pinpoint the relationships between various variables, but finds it challenging to give details on the causal relationships between the variables (Schanzenbach, 2012). To this end, the research sought to compare the outcomes of applying both virtual simulation and traditional lab instructional techniques. Despite the fact that the research established that the two instructional strategies did not result in significant differences in the learning outcomes for the students, the research design was unable to give reasons behind these findings. The implication is that there was a need to employ more intense research designs that could give details explaining the findings. This builds on the literature that suggests that experimental researchers need to apply designs that complement their research design in a bid to yield richer data (Odle & Mayer, 2009).

Another limitation of this research was the aspect of unseen defects within the subjects. In a conventional research setting, a researcher seeks to have subjects who have uniform characteristics in terms of age, heath status and gender (Schanzenbach, 2012). To this end, this study sought to use subjects who were within the same level of learning, and who were of relatively the same age. The limitation of subjects' defects arises from the fact that there is the possibility of certain unforeseen differences within the subjects used in the research. When the subjects have such defects, there is a possibility of the defects leading to the realization of false findings. The subjects, in this case, may have had differences in regards to their genetic wiring, which has the potential of influencing findings. Such unseen differences and defects may have influenced the findings of the research in one way or the other. The implication is that the

inferences drawn from the research are incorrect because of the differences and defects within the subjects.

The research also had a confounder limitation. Confounder limitations refer to factors with the ability to affect the results of a study, but limitations that are not considered by the researcher (Schanzenbach, 2012). To this end, one possible confounder was the aspect of maturity, especially in regards to the use of virtual simulation techniques. After the study was complete, the researcher established that the effective use of virtual learning programs was more effective for mature users as opposed to younger users. Given the fact that the maturity variable was not considered during the research, it may have affected the findings. In addition, the fact that the aspect of maturity cannot be effectively measured makes this confounder a real threat to the findings of the research. In this case, age was used to gauge the maturity level of the subjects, but cannot be regarded as a foolproof measure of maturity. Further research building on this study, therefore, needs to take into consideration the impact of the maturity confounder.

The study also had the limitation of time used and the timings applied. Due to other constraints facing the researcher, the study was conducted within a limited period. The aspect of time as a limitation to experimental research occurs where the effectiveness of a program is measured soon after its introduction (Odle & Mayer, 2009). To this end, the application of virtual simulation cannot be regarded as an entirely new concept in the laboratory settings, but it can be agreed that the virtual learning concept is still in its infancy stages especially in physical sciences. To this end, there is a possibility that as the virtual learning concepts are continuously rolled out, better outcomes are realized. To this end, therefore, the results of this study may be a faulty representation of the situation in the future. The possibility of the situation changing in the long run reduces the viability of this study. It would have been preferable for the study to take a

more longitudinal approach, where the subjects were observed over a long period of time. Time, therefore, was a major limitation to this research.

The study also faced the question of its external validity. In educational research, researchers are often faced with the question of whether the results of a study can be replicated in a different location or when a different set of subjects is used (Schanzenbach, 2012). This is always a challenge to researcher since, in the ideal situation, the findings of a study need to be universally applicable. There is, however, the chance of the findings not being replicated elsewhere. In this particular study, the researcher used a small number of subjects from a single setting. The implication is that the findings of the study may only be applicable in that particular setting. The failure to conduct the research on a wider setting, therefore, poses a challenge to the external validity of the findings of this research. The insight gained from the study may only be applicable to locations and settings with the identical characteristics of the study area. Given that, that proposition is highly unlikely, the findings may not be applicable to a larger population.

Another possible limitation to this study was the Hawthorne Effect. This effect refers to the possibility of the subjects involved in a study changing their mannerisms as a result of acknowledging that they are being watched (Odle & Mayer, 2009). It is natural for a person to change their behavior once they identify that their actions are being watched or measured. The subjects of an experiment may, therefore, deviate from their normal patterns of behavior, making the research findings to be an untrue reflection of the normal subject behavior. In this study, the main question being measured was the achievement of the learners because of the application of either virtual simulation or traditional lab instructional techniques. If the subjects were aware that their performances were being observed, the Hawthorne Effect may have come into play, where they altered their behavior. This may have resulted in the realization of performances higher than

normal, or performances lower than normal. To this end, the real relationships between the variable may be different when the subjects know they are not being watched or their performance is being measured.

Another major limitation came in the form of costs. Experimental research designs are usually an expensive venture that requires a heavy financial input to effectively carry out all the research activities (Schanzenbach, 2012). The cost limitation may, therefore, result in the realization of results that are not a true representation of the study. This is because the researcher is constrained and is not able to gather the required or sufficient data. In this case, the researcher faced the cost constraint given the fact that the study was self-sponsored. To this end, there was the limitation of the level of manipulation of the subjects and variable, which would have otherwise led to richer data. The limits in budget meant that the researcher used a small sample, and did not enlist the services of experts in various stages of the research. To this end, there is the possibility of the study having more errors, which would have been dealt with through better funding of the research.

**Basis of future research**

The findings of this study have a variety of impacts to future research. Researchers in physical science education need to look into the nature of problems that face different laboratory settings. Scholars in different fields of science education agree with the proposition that the laboratory plays an important role in improving the learning outcomes for science students (Tüysüz, 2010). To this end, most researchers have looked into the problems that face traditional laboratory settings. Such problems include the expensive nature of laboratory equipment, the time required for planning, the difficulties in measuring student performances and the difficulty in coming up with perfect lab conditions for conducting experiments. With this study having

established that virtual simulation is equally effective as traditional laboratory instructional techniques, further research needs to be conducted on aspects that affect efficiency in virtual labs. This will be done with the goal of coming up with solutions to the problems associated with virtual learning and ensuring that learners get the best out of these settings.

Further research also needs to be conducted with the goal of conceptualizing the real benefits of the use of virtual reality techniques in the laboratory. Given the technological age we live in, technological advancements are occurring in virtually all the facets of life. Instructional techniques, especially in physical sciences, cannot risk being left behind, necessitating further research on the exact benefits of the concept of virtual reality in laboratory settings. A review of the literature on the benefits of applying virtual reality concepts in laboratory settings shows that researchers focus on the institutional benefits of this technology. To this end, virtual simulation has been identified to help in the overcoming of the myriad of problems experienced in the traditional labs such as problems to so with space, finances, planning, and safety. Researchers should, however, look into the benefits from the learners' perspective, with the goal of conceptualizing how learners stand to benefit from the use of virtual reality in laboratory settings.

Further research also needs to be conducted on how simulations can be better structured to meet the goals of experiments, especially in physical science. The study made the realization that there were no significant differences in the performances of students subjected to either virtual simulations or traditional lab instructional techniques. It was, therefore suggested that in some cases, the application of virtual reality techniques may be resulting in the failure of students to develop the skills that come with laboratory work. Virtual learning possibly stifles skills such as creativity. Research, therefore, needs to be conducted to establish whether such

arguments are valid. In addition, researchers need to be conducted on how virtual learning environments in physical science learning can be designed to meet all the needs of the students. Such research will go a long way in informing policy makers on how virtual learning can be optimized to help students gain skills and expertise in physical science.

This research also realized that gender is an important aspect to consider when gauging the effectiveness of different instructional techniques. The study established that there was a difference in the academic outcomes of male learners and their female counterparts when the virtual simulation was applied in a laboratory setting. The findings indicated that male learners seemed to perform better when they were subjected to virtual simulations. The female learners posted lower performances, suggesting that virtual reality learning did not positively affect the female learners. Researchers need to look into this scenario in detail, with the goal of realizing the factors that underlie the poor performance of female learners once virtual learning is introduced. This research should inform policy makers on how a level academic platform for both male and female learners can be realized especially once a technology is used in instructional techniques.

Another area of research that should be emphasized is the impact ethnicity has on the effectiveness of different instructional techniques. This research revealed there was a significant difference in the outcomes of the students who were subjected to different instructional techniques. According to the findings, Hispanics performed better when subjected to traditional instructional techniques, while African-Americans posted better results when virtual simulations were introduced. To this end, there is a wide informational gap on how different ethnicities are impacted by different instructional techniques. Research needs to be conducted to provide insight on the best instructional techniques that apply to different ethnicities. This is to avoid the mistake

of assuming that all types of instructional techniques affect all the learners uniformly. Obtaining this knowledge will enable stakeholders to bridge the gap in the educational outcomes for students from different ethnic backgrounds. In addition, such insight will be instrumental in showing how different instructional techniques can be optimized to meet the needs of students from different ethnicities. This will help in ensuring that the educational offerings for all students are leveled, with the goal of realizing greater academic achievement.

This research, having established the absence of significant differences in the performance of learners subjected to different instructional lab techniques points at a need to research on how the two approaches can be brought together. The study established that virtual simulation and traditional lab instructions both have strong points that are beneficial to the science learners. Further research, therefore, needs to be conducted on how the two approaches can be brought together into a complementary relationship. Some researchers have focused on examining the individual benefits of the two approaches, with literature lacking on the benefits of applying the two methodologies jointly. There is, therefore, a gap of knowledge regarding the application of multiple instructional techniques in a single setting.

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**Appendix A**

**Bench Mark Test**

## Unit II Benchmark Test-Force and Motion

---

Select the best answer for each of the following questions:

---

**1.** A car traveling at a velocity of 50 mph crashed into a brick wall. What is the velocity of the driver the moment after impact if the driver was not wearing his seat belt?

○ **A.** 30 mph

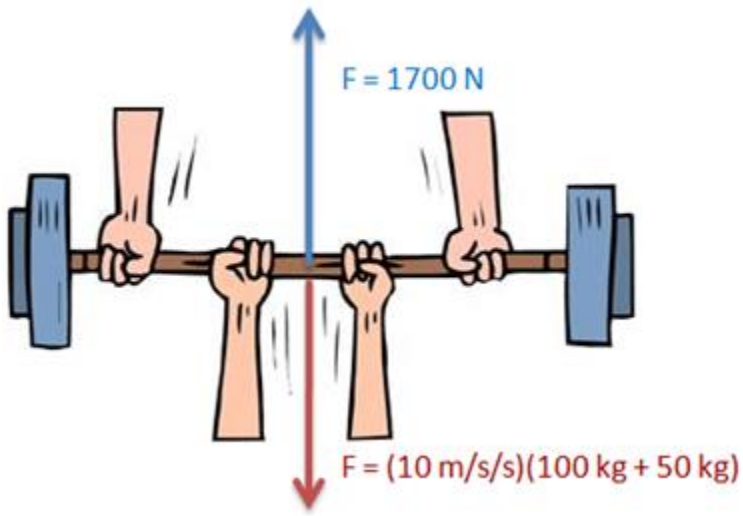
○ **B.** 40 mph

○ **C.** 0 mph

○ **D.** 50 mph

---

**2.** Examine the picture below.



If a 100 kg man hangs from a 50 kg barbell while another man pulls him and the barbell upwards with a force of 1700 N, what is the approximate net force of this system?

*Hint: Assume that 1 kg equals approximately 10 N of force, or 10 N = (1 kg)(10 m/s/s).*

- **A.** 200 N upwards
- **B.** 200 N downwards
- **C.** 1550 N upwards
- **D.** 1550 N downwards

---

**3.** The Smiths went out to cut down their Christmas tree for this year. Along with their truck, Mr. Smith brought his two sons and an axe. Why did Mr. Smith bring an axe with him?

- **A.** The axe is used to shave the bark off of the tree.
- **B.** He uses the axe to carry the tree back to the car.
- **C.** Mr. Smith uses the axe to scrape the snow off of his car.
- **D.** The axe requires less effort to do the same work.

---

**4.** When an inclined plane is used,

- **A.** a smaller force is exerted over a longer distance.
- **B.** a negative mechanical advantage can result.
- **C.** the mechanical advantage increases as the height increases.
- **D.** a greater force is exerted over a shorter distance.

---

**5.** Examine the picture below.

One of the boys on the right pulls with a force of 200 N. The other boy on the right pulls with a force of 300 N. However, the boy on the left doesn't move anywhere. What is the net force of this system?

- **A.** 0 N
- **B.** 500 N to the right
- **C.** 500 N to the left
- **D.** There is not enough information given to answer this question.

---

**6.** If it takes 560 Joules of work to move an object 5 meters, what force was needed?

- **A.** 112 N
- **B.** 555 N
- **C.** 114 N
- **D.** 565 N

---

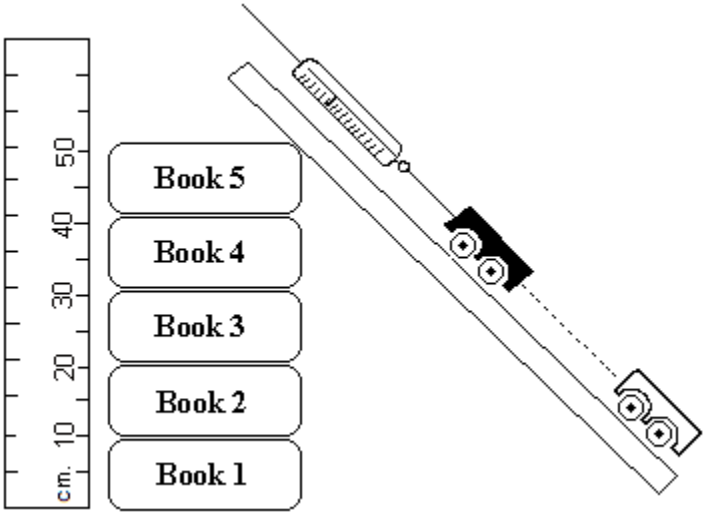
**7.** Inertia is

- **A.** a force that keeps objects in motion.
- **B.** a principle that describes the difference between mass and weight.

◯ **C.** a net force that keeps gravitational forces in balance.

◯ **D.** a property of an object to resist changes in its velocity.

---




Inclined planes make work easier by decreasing the size of the input force. The amount by which the inclined plane multiplies the input force, ignoring friction, is called the ideal mechanical advantage (I.M.A.). This can be determined by dividing the length of the plane by its height. The weight of the cart used in the study was 240 Newtons (N).

| Number of books | Height of plane (cm) | Length of plane (cm) | Estimate I.M.A. of inclined plane | Expected force (N) |
|---|---|---|---|---|
| 1 | 10 | 120 | 12.0 | 20 |
| 3 | 30 | 120 | 4.0 | 60 |
| 5 | 50 | 120 | 2.4 | 100 |

**8.** Which of the following statements best describes the data shown in the table provided?

◯ **A.** Decreasing the height of the inclined plane decreases the I.M.A. of the inclined plane.

◯ **B.** Decreasing the height of the inclined plane increases the weight of the cart.

◯ **C.** Increasing the height of the inclined plane decreases the weight of the cart.

◯ **D.** Increasing the height of the inclined plane decreases the I.M.A. of the inclined plane.

---

**9.** Force times the distance traveled in the direction of that force is referred to as _____.

◯ **A.** work

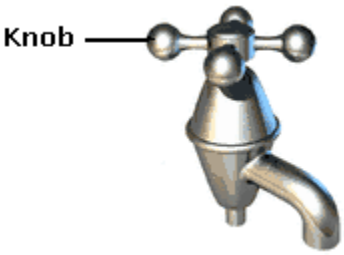
◯ **B.** momentum

◯ **C.** power

◯ **D.** velocity

---

**10.**




What type of simple machine is the knob of this water faucet?

◯ **A.** wedge

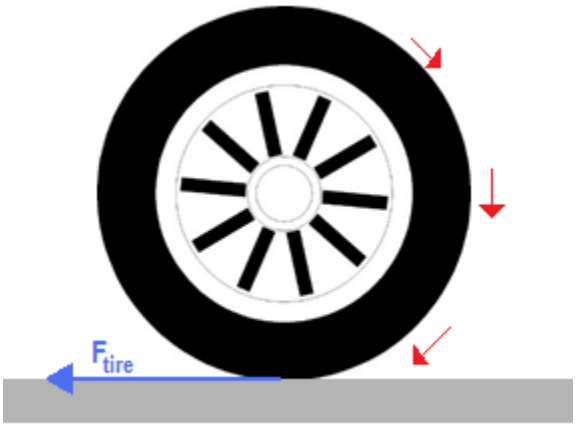
◯ **B.** pulley

◯ **C.** wheel and axle

◯ **D.** inclined plane

---

**11.** Rebecca is sitting at a stop light in her convertible when the light turns green. As she begins to push on the gas pedal, this causes the wheels to spin. At the place where the tires meet the road, the tires push backward on the road with a frictional force.




What force pushes the car forward?

- **A.** an equal gravitational force from the Earth
- **B.** an equal static frictional force from the road
- **C.** an equal spring force from the engine
- **D.** an equal kinetic frictional force from the axles

---

**12.** What is the force that is primarily involved with a falling object?

- **A.** nuclear
- **B.** magnetic
- **C.** electric
- **D.** gravity

---

**13.** Jeremy has a strong magnet. He put a paper clip on his desk and held the magnet sixteen centimeters over the paper clip. If the paper clip has a mass of 1 gram, and the magnet exerts a force of 0.015 Newtons on the paper clip to pull it off the desk, what is the acceleration of the paper clip as it flies off the desk toward the magnet?
(Ignore gravity.)

- **A.** 15 $m/s^2$

- **B.** 1.015 $m/s^2$
- **C.** 240 $m/s^2$
- **D.** 0.24 $m/s^2$

---

**14.** A crate is at rest on the ground. What force or forces are acting on the crate?

- **A.** The weight of the crate is acting downward on the ground and the ground is exerting a force equal to the weight of the crate upward on the crate.
- **B.** The weight of the crate is acting downward on the crate.
- **C.** There are no forces acting on the crate.
- **D.** The ground is exerting a force equal to the weight of the crate upward on the crate.

---

**15.** Look at the pictures shown.

In each of these pictures, gears create a mechanical advantage. Which kind of simple machine do these gears represent?

- **A.** lever
- **B.** screw
- **C.** wheel and axle
- **D.** pulley

---

**16.** Work is defined as applied force acting through a distance, and it can be calculated according to the following formula:

$$W = F \times d$$

where *F* is the force that is applied and *d* is the distance that an object moves in the direction of the applied force.

In which of the following scenarios is the most work performed?

- **A.** The same amount of work is performed in all of these scenarios.
- **B.** A woman pushes a couch 2 meters across the floor with a force of 500 N.
- **C.** A man pushes on a car with a force of 1000 N, but the car doesn't move.
- **D.** A girl carries a 10 N box 100 meters across her backyard.

---

**17.** Jenn and her friends are pushing her car from the back with a force of 1407 N. Which of the following forces if applied to the front of the car, will make the car roll backward?

- **A.** 1001 N
- **B.** 986 N
- **C.** 1400 N
- **D.** 1408 N

---

**18.** How much force is needed to accelerate a 9,760 kg airplane at a rate of 4.9 $m/s^2$?

- **A.** 172,166 N
- **B.** 1,992 N
- **C.** 47,824 N
- **D.** 13,284 N

---

**19.** How does a simple pulley make it easier to lift an object?

- **A.** by making the object lighter
- **B.** by reducing the force needed to lift the object
- **C.** by decreasing the distance over which the force is applied
- **D.** by changing the direction of the input force

---

**20.** A man drops a baseball off of the top of the Empire State Building. If the action force is the pull of the Earth on the ball, then what is the reaction force?

- **A.** gravity
- **B.** there is no reaction force
- **C.** the acceleration of the ball
- **D.** the pull of the ball on the Earth

## Unit V Wave Benchmark

---

Select the best answer for each of the following questions:

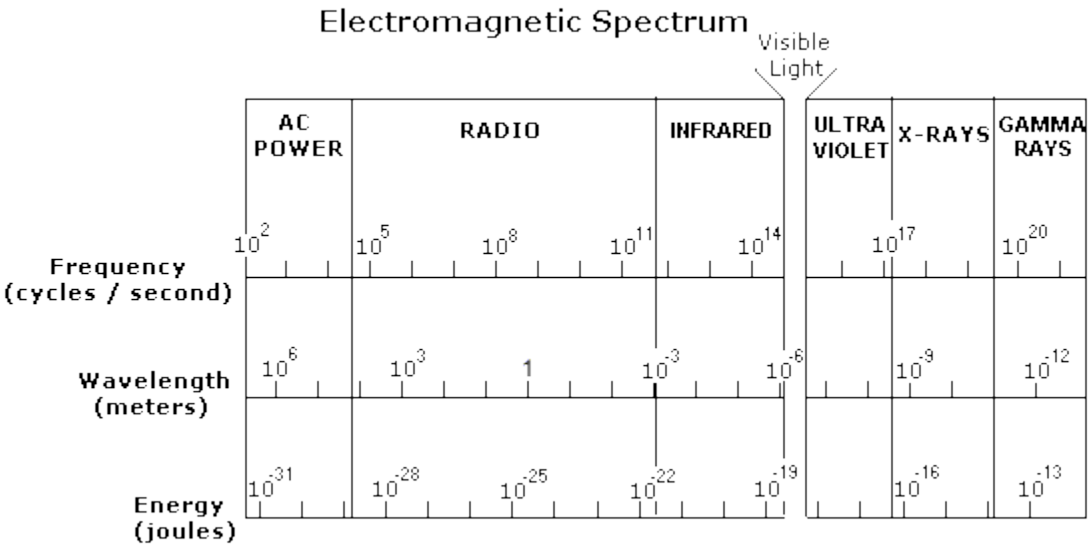
---

**1.** In order to see an object

- **A.** light must be emitted by or reflected off of that object.
- **B.** the object's atoms must be arranged in a crystalline pattern.
- **C.** the object can only be in a solid state of matter.
- **D.** light must be able to pass through the object.

---

**2.**




According to this chart the longer the wavelength

- **A.** the less energy the wave has.
- **B.** the faster the wave travels.
- **C.** the greater the frequency of the wave.
- **D.** the larger the amplitude of the wave.

---

**3.** The use of sound waves helps scientists find out how deep parts of the ocean are. The scientists do this by sending a sound wave to the floor of the ocean and recording the time it takes to return to a machine. What did the inventor of this machine need to know while developing the machine?

- **A.** The speed of light waves in water.
- **B.** The speed of water waves.
- **C.** The speed of sound waves in water.
- **D.** The speed of sound waves in air.

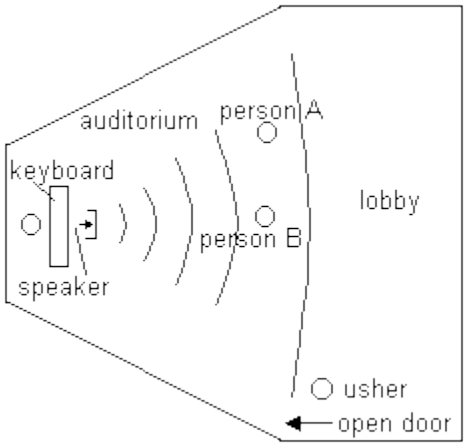
---

**4.** Which of the following is a true statement about waves?

- **A.** All waves travel longitudinally and compressionally at the same time.
- **B.** Waves can transfer energy when they interact with matter.
- **C.** All waves require a medium through which they can travel.
- **D.** Waves are never affected when they interact with matter.

---

A band is giving a concert in an auditorium. When a musician plays a note on the keyboard, the speakers vibrate back and forth at a particular frequency. These vibrations travel through the air as a sound wave toward the audience (see the figure below).




As shown in the table below, different notes, or pitches, have different frequencies, and wavelengths.

The speed of sound in dry air at 20° C is 343 m/sec and increases by 0.59 m/sec for each degree Celsius above 20° C. Wave speed is equal to wavelength x frequency.

## Pitch Frequencies and Wavelengths at 20°C

| Note (pitch) | Frequency (1/sec) | Wavelength (m) |
|---|---|---|
| low A | 440 | 0.780 |
| B | 494 | 0.694 |
| C | 523 | 0.656 |
| D | 587 | 0.584 |
| E | 659 | 0.520 |
| F | 698 | 0.491 |

| | | |
|---|---|---|
| G | 784 | 0.438 |
| high A | 880 | 0.390 |

**5.** An usher stands in the lobby, out of sight of the band, and listens to the music. Which of the following is the most reasonable explanation why the usher can hear the music and yet not be in front of the open door?

- **A.** The sound waves have strong interference at these wavelengths.
- **B.** The sound waves are refracted by the cooler air in the lobby.
- **C.** The sound waves are diffracted through the door opening.
- **D.** The sound waves are reflected by the many people in the auditorium.

---

**6.** Waves transfer _____ from one place to another without transferring _____.

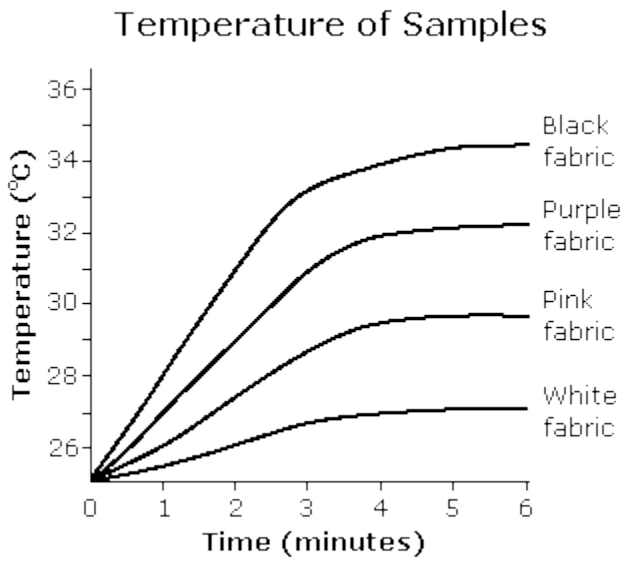
- **A.** energy; mass
- **B.** mass; matter
- **C.** matter; energy
- **D.** mass; energy

---

## HOT

During the summer a student noticed the color of the clothes she wore affected how hot she felt. The student designed an experiment to test this.

The student obtained four identical samples of sand. Each sample was covered with a different color of cotton fabric. Each sample was then placed directly under a 110-watt lightbulb. The student recorded the initial temperatures of the sand, then turned on the lamps. At one-minute intervals, for six minutes total, the student measured the temperature of each sample. The data is shown in the graph below.

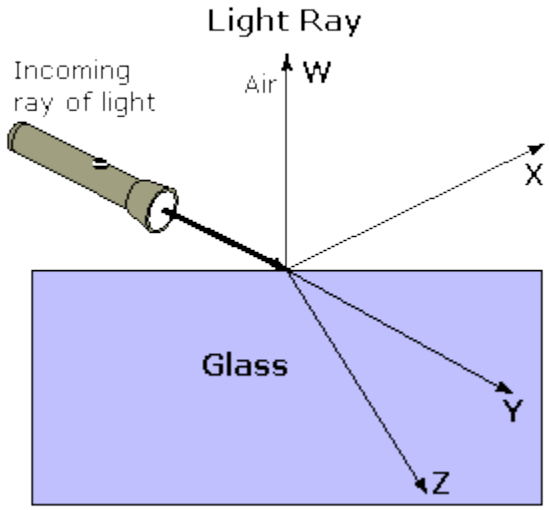



**7.** Solar collectors are used to absorb energy from the Sun. This energy is then used to heat homes. According to the data from this experiment, what color should solar collectors be to maximize energy absorption?

- **A.** purple
- **B.** pink
- **C.** black
- **D.** white

---

**8.**



Which of these arrows would represent the path of a refracted ray of light?

- **A.** X
- **B.** W
- **C.** Y
- **D.** Z

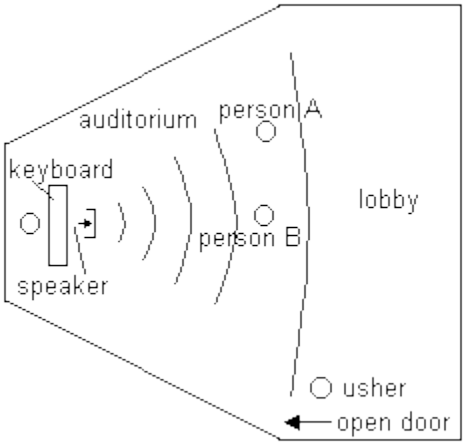
---

**9.** Which of the following best explains why the curves in the figure flattened out after a period of time?

- **A.** The samples began to absorb all of the light energy emitted by the light bulb.
- **B.** The light bulbs ran out of electricity to supply to the samples.
- **C.** The samples were releasing energy at about the same rate as they were absorbing energy.
- **D.** The samples began to reflect all of the light energy.

---

A band is giving a concert in an auditorium. When a musician plays a note on the keyboard, the speakers vibrate back and forth at a particular frequency. These vibrations travel through the air as a sound wave toward the audience (see the figure below).

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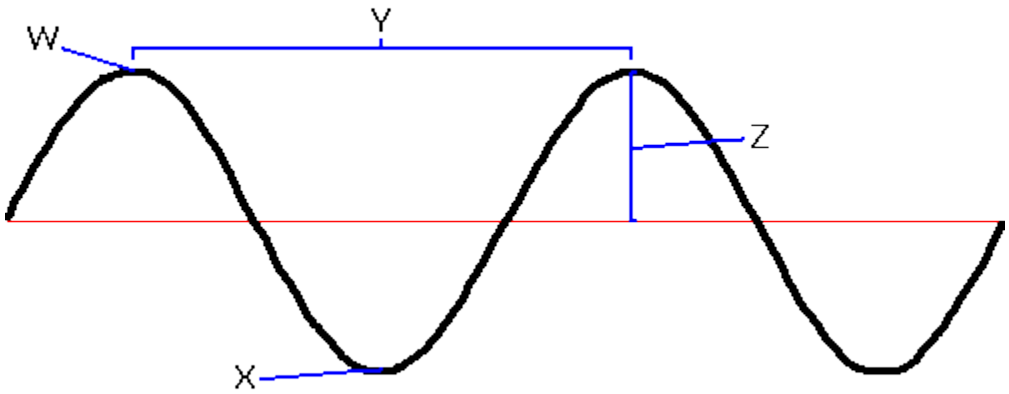
| D | 587 | 0.584 |
| E | 659 | 0.520 |
| F | 698 | 0.491 |
| G | 784 | 0.438 |
| high A | 880 | 0.390 |

**10.** Assume that the auditorium warms up from 20.0° C to 25.0° C during the concert. What would be the wavelength of the note $A_{440}$ at 25.0° C?

- **A.** 0.803 m
- **B.** 0.656 m
- **C.** 0.778 m
- **D.** 0.786 m

---

**11.** Which letter corresponds to the **trough** of the wave?



- **A.** W
- **B.** X
- **C.** Y
- **D.** Z

---

**12.** Which of the following statements supports the claim that sound is energy that is transferred by a wave, not energy transferred by particles?

- **A.** Sound waves not only transfer energy; they also transfer matter or mass.
- **B.** When sound travels through a medium such as air, the air particles experience a disturbance but return to their original positions.
- **C.** When sound travels through a medium such as air, the air particles move from their starting location to a contact location in order to transfer energy.
- **D.** Sound waves do not require a medium through which to transfer energy.

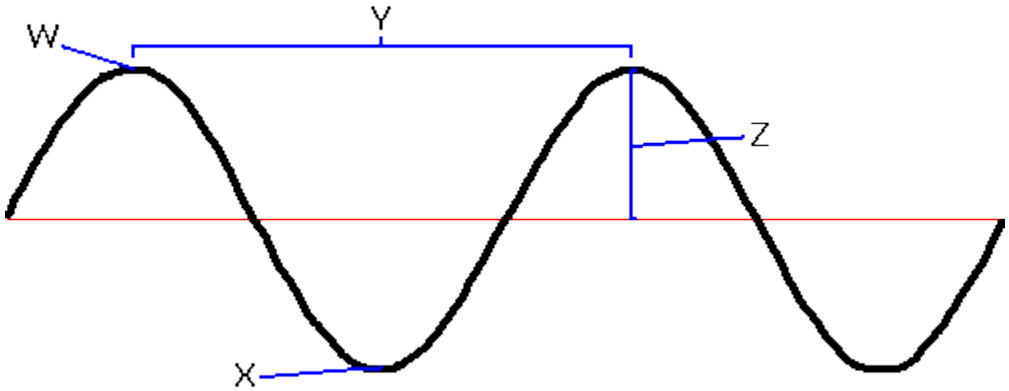
---

**13.** Which of the following is an example of a compressional or longitudinal wave?

- **A.** light waves from the Sun
- **B.** a ribbon waving up and down in a dance routine
- **C.** a water wave in the ocean
- **D.** a toy clown bouncing up and down on a spring

---

**14.** Which letter corresponds to the **crest** of the wave?




- **A.** X
- **B.** W
- **C.** Y
- **D.** Z

---

A scientist is working in the research division of a company that makes light filters and protective eyewear. He uses three ways to reduce light intensity depending on what is needed: absorption, reflection, and polarization (see Figures A, B, and C).

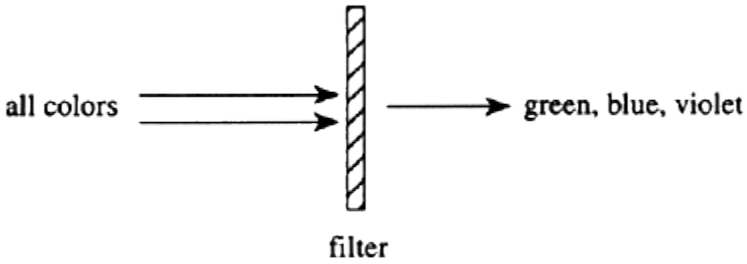



Figure A

Absorption: Atoms in this filter absorb red, orange, and yellow and allow the other colors to pass through.

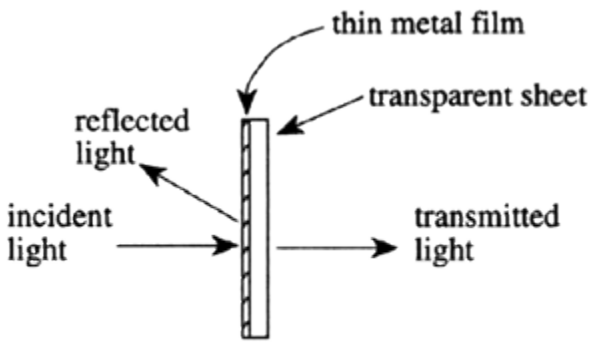



Figure B

Reflection: Some of the light is reflected by the thin metal film; the rest passes through.

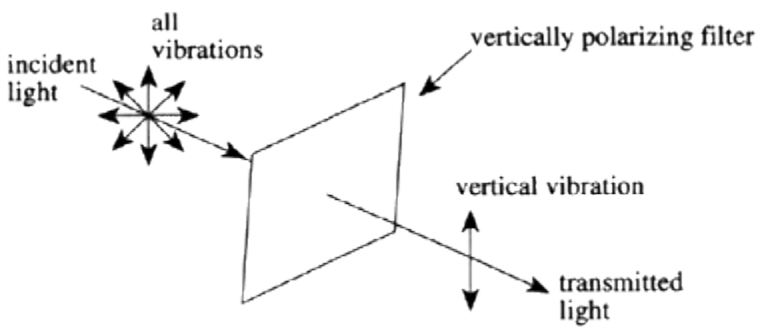



Figure C

Polarization: This filter only allows vertical vibrations (polarization) to pass through; the rest are absorbed.

**15.** What happens to the energy of light absorbed in an absorbing filter?

- **A.** It changes to heat energy.
- **B.** It changes to nuclear energy.
- **C.** It passes completely through the filter without being changed.
- **D.** It changes to gravitational potential energy.

---

**16.** Which of the following principles is involved when you see a transparent object, such as a clear plastic straw or a piece of glass, in a clear liquid?

- **A.** interference

- **B.** refraction
- **C.** absorption
- **D.** resonance

---

**17.** Compressional or longitudinal waves vibrate

- **A.** in irregular patterns. There is no way to describe the direction of the motion.
- **B.** in alternating directions. Sometimes the direction is perpendicular to the motion; sometimes it is in the same direction.
- **C.** perpendicular to or at right angles to their direction of motion.
- **D.** in the same direction as they are moving.

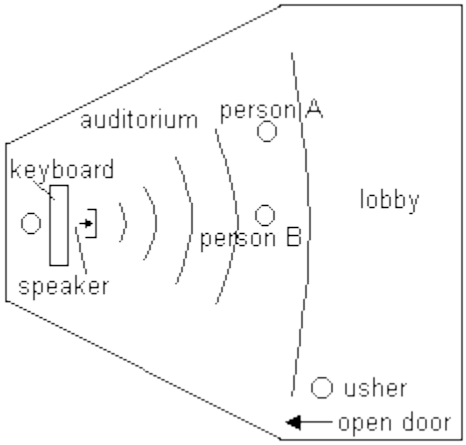
---

**18.** What are electromagnetic waves, including radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, x-rays, and gamma rays, a result of?

- **A.** a low volume of electricity
- **B.** a charged object decelerating
- **C.** a charged object accelerating
- **D.** a high volume of electricity

---

A band is giving a concert in an auditorium. When a musician plays a note on the keyboard, the speakers vibrate back and forth at a particular frequency. These vibrations travel through the air as a sound wave toward the audience (see the figure below).




As shown in the table below, different notes, or pitches, have different frequencies, and wavelengths.

The speed of sound in dry air at 20° C is 343 m/sec and increases by 0.59 m/sec for each degree Celsius above 20° C. Wave speed is equal to wavelength x frequency.

## Pitch Frequencies and Wavelengths at 20°C

| Note (pitch) | Frequency (1/sec) | Wavelength (m) |
|---|---|---|
| low A | 440 | 0.780 |
| B | 494 | 0.694 |
| C | 523 | 0.656 |
| D | 587 | 0.584 |
| E | 659 | 0.520 |
| F | 698 | 0.491 |
| G | 784 | 0.438 |
| high A | 880 | 0.390 |

**19.** According to the table above, what happens to the wavelength of sound if the pitch increases from $A_{440}$ to $A_{880}$?

- **A.** The wavelength decreases.
- **B.** The wavelength increases.
- **C.** The wavelength increases then decreases.

◯ **D.** The wavelength remains constant.

---

**20.** If a water wave moves under an object such as a fishing bobber or a buoy, the object does not move forward as the wave passes under it. Why?

◯ **A.** The wind always blows on an object in the opposite direction of the wave motion.

◯ **B.** Waves travel at great depths so they cannot affect objects on the surface of the water.

◯ **C.** The water molecules vibrate perpendicular to the direction of the wave motion.

◯ **D.** The water molecules oscillate forward and then backward so the motion is not detectable.

---

## Unit VI- Electricity Benchmark Test

---

Select the best answer for each of the following questions:

---

**1.** A glass rod becomes electrically charged when rubbed with a silk cloth. What charge does the glass rod acquire?

◯ **A.** It gains neutrons and becomes negatively charged.

◯ **B.** It loses electrons and becomes positively charged.

◯ **C.** It loses electrons and becomes negatively charged.

◯ **D.** It gains electrons and becomes positively charged.

---

**2.** Calculate the current if voltage = 61.2 V and resistance = 3.4 ohms.

◯ **A.** 374.544 A

◯ **B.** 3,745.44 A

- **C.** 436.81 A
- **D.** 18 A

---

**3.** Which of the following materials is it most difficult for electrons to flow through?

- **A.** aluminum
- **B.** gold
- **C.** salt water
- **D.** glass

---

**4.** A conducting wire is placed inside a magnetic field. When the wire is rotated, an electrical current runs through it. Which of these best explains why the wire needs to be rotated?

- **A.** The rotation of the wire converts heat energy to electrical energy.
- **B.** The rotation of the wire causes it to become magnetized.
- **C.** The movement of the wire generates the magnetic field.
- **D.** The movement of the wire within the magnetic field produces the current.

---

**5.** Gene has a string of lights on a series circuit. What will occur if one of the light bulbs on the circuit burns out?

- **A.** The burnt out bulb will begin to blink.
- **B.** Nothing will happen to the rest of the bulbs.
- **C.** All of the light bulbs will go out.
- **D.** The light bulbs after the burnt out bulb will go out.

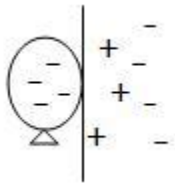
---

**6.** Which of the following electromagnetic devices are used by electricians to measure the current flowing through wires in a house?

- **A.** galvanometer
- **B.** mass spectrometer
- **C.** cathode ray tube
- **D.** DC motor

---

**7.** If you rub a balloon on your shirt or your hair and then place the balloon against the wall, the balloon will stick.

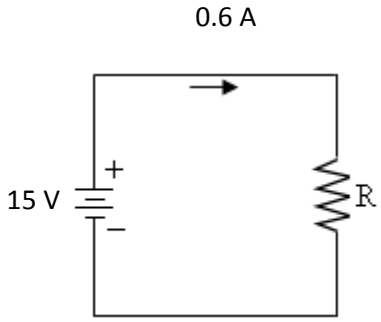


How is it able to do this?

- **A.** The positive charges in the balloon are attracted to the negative charges in the wall.
- **B.** The negative charges in the balloon are attracted to the positive charges in the wall.
- **C.** The positive charges in the balloon are attracted to the positive charges in the wall.
- **D.** The negative charges in the balloon are attracted to the negative charges in the wall.

---

**8.** What is the resistance in this circuit?




- **A.** 2.5 ohms

- **B.** 0.04 ohms
- **C.** 25 ohms
- **D.** 9 ohms

---

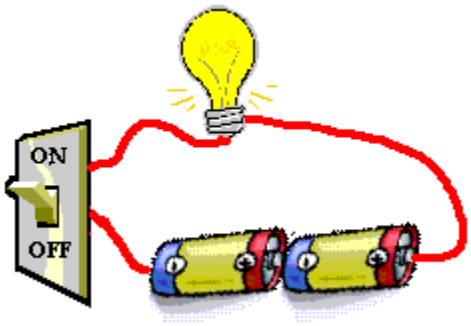
**9.** A cathode ray tube is an electromagnetic device that is used almost daily in life. It is made of an electron gun which has a heated filament and a supply of electrons. It also has two pairs of deflecting plates, known as the anode (positive) and the cathode (negative), which accelerate the electrons. Electrons leaving the gun are deflected by the plates and are scanned into a fluorescent screen or monitor.

What everyday device does the cathode ray tube resemble in function?

- **A.** voltmeter
- **B.** motor
- **C.** Microwave
- **D.** television

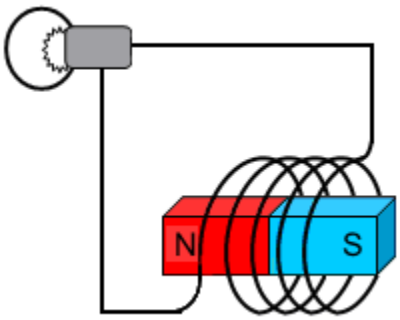
---

**10.** Look at the circuit below. What type of circuit is being shown?




- **A.** a series circuit
- **B.** a parallel circuit
- **C.** This is not a circuit.
- **D.** an incomplete circuit

**11.** For his science fair project, Edgar wants to create a simple generator to produce electricity. To do this, he places a magnet in the middle of coils of wire that are attached to a light bulb.




After completing his project, however, the light bulb does not light up. Why?

- **A.** He needs to wrap the magnet with a different kind of wire.
- **B.** The magnet needs to be in motion, not stationary.
- **C.** He needs to use a different kind of light bulb.
- **D.** The magnet can remain stationary, but the polarity must be reversed.

---

**12.** Monica has a string of lights on a parallel circuit. What will occur if one of the light bulbs on the circuit burns out?

- **A.** Nothing will happen to the rest of the bulbs.
- **B.** The light bulbs after the burnt out bulb will go out.
- **C.** The burnt out bulb will begin to blink.
- **D.** All of the light bulbs will go out.

---

**13.** The electric force between two charged objects _____ as the distance between them increases and _____ as the magnitudes of their charges increase.

- **A.** decreases; increases

- **B.** decreases; decreases
- **C.** increases; increases
- **D.** increases; decreases

---

**14.** How do protons and electrons differ in their electric charge?

- **A.** Protons are neutral; electrons are negatively charged.
- **B.** Protons are negatively charged; electrons are positively charged.
- **C.** Protons are positively charged; electrons are negatively charged.
- **D.** Protons are positively charged; electrons are neutral.

---

**15.** Which of the following could be the source of resistance in a household electric circuit?

- **A.** a toaster
- **B.** a stove
- **C.** a light bulb
- **D.** all of these

---

**16.** For an Ohmic conductor, tripling the voltage without changing the resistance will cause the current to

- **A.** Decrease by a factor of 9.
- **B.** Decrease by a factor of 3.
- **C.** Increase by a factor of 9.
- **D.** Increase by a factor of 3.

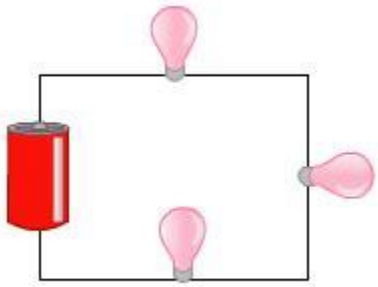
---

**17.** It is a cold, winter day. When you remove your wool snow hat, your hair stands up. Why does it do this?

- **A.** Each hair gains electrons, becomes negatively charged, and attracts the other hairs on your head.
- **B.** Each hair loses electrons, becomes negatively charged, and attracts the other hairs on your head.
- **C.** Each hair loses electrons, becomes positively charged, and repels the other hairs on your head.
- **D.** Each hair gains electrons, becomes positively charged, and repels the other hairs on your head.

---

**18.** If one of the bulbs is removed from the circuit below, and the circuit remains closed, the other bulbs will



- **A.** Glow with lesser intensity.
- **B.** Maintain the same brightness.
- **C.** Stop glowing.
- **D.** Glow with greater intensity.

---

**19.** What is an electrical current?

- **A.** opposition to the flow of electricity
- **B.** the amount of energy available to move electrons
- **C.** the flow of electrons through a wire
- **D.** a build-up of electrons in a centralized location

---

**20.** What is voltage?

- **A.** the flow of electrons through a wire
- **B.** the amount of energy available to move electrons
- **C.** opposition to the flow of electricity
- **D.** a build-up of electrons in a centralized location

---

## Unit VII Matter Benchmark Test

---

Select the best answer for each of the following questions:

---

**1.** The density of liquid water at room temperature is approximately 1.0 g/mL. The density of ice is 0.92 g/mL. So, freezing the liquid water into solid ice changes _____ of water.

- **A.** the chemical composition
- **B.** a chemical property
- **C.** a physical property
- **D.** a physical property and the chemical composition

---

**2.** Two identical balloons are filled with the same volume of air and connected to each other by a small piece of plastic tubing. If one of the balloons is compressed, the other balloon fills with a greater volume of air. Which of the following explains this phenomenon?

- **A.** Gay-Lussac's Law
- **B.** Charles' Law
- **C.** Avagadro's Law

○ **D.** Boyle's Law

---

**3.** Gay-Lussac's law relates the pressure of a gas to its temperature in Kelvin according to the following formula.

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Given this information, which of the following statements is true?

○ **A.** If the temperature of a gas is halved, its pressure will decrease exponentially.

○ **B.** If the temperature of a gas is doubled, its pressure will also double.

○ **C.** If the temperature of a gas is doubled, its pressure will increase exponentially.

○ **D.** If the temperature of a gas is halved, its pressure will double.

---

**4.** _____ are the most common phase of matter in the universe.

○ **A.** Gases

○ **B.** Liquids

○ **C.** Solids

○ **D.** Plasmas

---

**5.** Plasma is a state of matter that consists of positively and negatively charged particles with little to no order in their arrangement. Substances can easily be converted to the plasma phase in stars, such as the Sun.

What condition is present on the Sun that allows plasmas to form?

○ **A.** small gravitational forces

- **B.** low oxygen levels
- **C.** high temperatures
- **D.** gusty winds

---

**6.** There are three main states of matter - solids, liquids, and gases. Particles in a solid are arranged

- **A.** Differently depending on the quantity of the solid substance.
- **B.** Somewhat close together, but they are free to flow.
- **C.** Very far apart - there is no ordered pattern.
- **D.** Very close together in an ordered, regular pattern.

---

**7.** Which of the following correctly lists the states of matter from the least particle movement to the most particle movement?

- **A.** solid, gas, liquid
- **B.** solid, liquid, gas
- **C.** liquid, solid, gas
- **D.** gas, liquid, solid

---

**8.** Which of the following correctly states Boyle's law?

- **A.** Volume is proportional to temperature.
- **B.** Volume is proportional to pressure.
- **C.** Volume is inversely proportional to pressure.
- **D.** Volume is inversely proportional to temperature.

---

**9.** Physical properties of matter can be observed without changing the identity of the substance. The phases of matter (e.g., solid, liquid, or gas) are physical properties. Solids are different from liquids and gases primarily because

- **A.** their particle shapes, hardness, and densities are different.
- **B.** their molecular motions and particle arrangements are different.
- **C.** their masses and molecular shapes are different.
- **D.** their colors and molecular masses are different.

---

**10.** A balloon is filled with air at room temperature. It is then dipped into liquid nitrogen at 77 K. The balloon collapses because

- **A.** the material becomes sticky.
- **B.** it develops a hole due to the decreased temperature.
- **C.** all the air inside the balloon condenses to form ice.
- **D.** the molecules inside the balloon slow down.

---

**11.** A container of an ideal gas is at a constant temperature. Which of the following occurs when the volume of the container is doubled from 1 liter to 2 liters?

- **A.** The pressure inside the container stays the same.
- **B.** The pressure inside the container is halved.
- **C.** The pressure inside the container is doubled.
- **D.** The pressure inside the container becomes zero.

---

**12.** The buoyancy force on a submarine submerged in the ocean equals

- **A.** The weight of the submarine.
- **B.** The volume of the submarine times the density of the ocean water.

- **C.** The density of the water displaced by the submarine.
- **D.** The weight of the ocean water displaced by the submarine.

---

**13.** Tracy has a small granite rock and makes a model of the rock out of Styrofoam. The model has the same size and shape as the rock. What would be the most noticeable difference between the rock and the model?

- **A.** ductility
- **B.** Volume
- **C.** Density
- **D.** conductivity

---

**14.** If an object has a mass of 4 g and a volume of 6 $cm^3$,
what is its density?

- **A.** 0.7 $g/cm^3$
- **B.** 2 $g/cm^3$
- **C.** 24 $g/cm^3$
- **D.** 1.5 $g/cm^3$

---

**15.** Jeff wants to find the volume of a gas in a cylinder. He knows that at 28°C and a pressure of 1 atm, the volume of the gas was 6.0 L. He measures the temperature and pressure and finds that the temperature is 39°C and the pressure has remained at 1 atm.

What would be the **best** for Jeff to use to find the volume of the gas?

- **A.** Charles' law
- **B.** Boyle's law
- **C.** Ideal gas equation

- **D.** Avogadro's law

---

**16.** Water is a unique substance because it can exist in all three states of matter within Earth's normal temperature range.
How do water molecules in the solid phase compare with water molecules in the gaseous phase?

- **A.** Solid water molecules are bigger than gaseous water molecules; this is why they are more visible.
- **B.** Solid water molecules are harder than gaseous water molecules; this is why ice is hard.
- **C.** The shape, size, and mass of water molecules do not change between the solid and gas phases.
- **D.** Solid water molecules are cube-shaped, like ice, while gaseous water molecules are round, like bubbles.

---

**17.** Many properties of gases, such as pressure and volume, and gas laws, such as Boyle's Law and Charles' Law, are based on assumptions of the kinetic molecular theory. Which of the following is a basic assumption of the kinetic molecular theory?

- **A.** The volumes of the individual gas particles play a significant role in the properties of gases.
- **B.** Particles in a gas move rapidly and constantly in a random pattern.
- **C.** Uncontained gases eventually reach a maximum volume and then change the direction of their motion.
- **D.** When gas particles collide, some of the kinetic energy is lost rather than transferred.

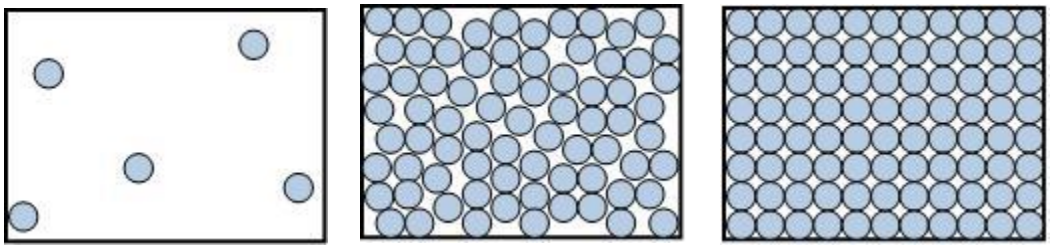
---

**18.** Which statement below describes Charles' law?

- **A.** Volume is inversely proportional to temperature.
- **B.** Volume is proportional to temperature.
- **C.** Pressure is proportional to temperature.
- **D.** Pressure is inversely proportional to temperature.

---

**19.** Which of the following diagrams depicts the particle arrangement in a gas?



**X.** **Y.** **Z.**

- **A.** Any of these diagrams could represent a gas.
- **B.** X
- **C.** Z
- **D.** Y

**20.** Density is a measure of how much _____ is _____ in a substance.

- **A.** electricity, conducted
- **B.** matter, packed
- **C.** oxygen, detected
- **D.** light, reflected

## Unit VIII Atom Benchmark Test

---

Select the best answer for each of the following questions:

---

**1.** The atomic mass of gold (Au) is 198, and the atomic number of gold is 79. How many neutrons does a neutral atom of gold contain?

- **A.** 198
- **B.** 99
- **C.** 119
- **D.** 79

---

**2.** The nucleus is the center of an atom. It consists of

- **A.** Neutrons and electrons.
- **B.** Neutrons alone.
- **C.** Protons and electrons.
- **D.** Protons and neutrons.

---

**3.** The term element refers to atoms that have the same number of _____.

- **A.** ions
- **B.** protons
- **C.** electrons
- **D.** neutrons

---

**4.** How can a neutral atom become a positively-charged particle?

- **A.** It could gain ions.
- **B.** It could gain neutrons.
- **C.** It could lose electrons.
- **D.** It could lose protons.

---

**5.** What is the name of the subatomic particles located farthest from the nucleus of the atom?

- **A.** valence electrons
- **B.** ionized neutrons
- **C.** negatively-charged ions
- **D.** reactive protons

---

**6.** Each element on the periodic table has a different number of isotopes, each one of which is present in nature in varying abundance. The relative abundance of an isotope is strongly correlated with

- **A.** Its electronegativity.
- **B.** Its phase of matter.
- **C.** Its number of valence electrons.
- **D.** Its tendency toward nuclear decay.

---

**7.** Which of the following subatomic particles is neutral (i.e., has no charge)?

- **A.** proton
- **B.** neutron
- **C.** electron
- **D.** nucleus

---

**8.** The atomic number of an element is determined by its number of _____.

- **A.** neutrons
- **B.** isotopes
- **C.** protons

- **D.** electrons

---

**9.** The atomic mass of an element can be approximated by adding the number of _____ plus the average number of _____.

- **A.** protons; isotopes
- **B.** protons; electrons
- **C.** protons; neutrons
- **D.** neutrons; electrons

---

**10.** Isotopes are different forms of the same element. Thus, isotopes always possess the same number of _____, but they possess a different number of _____.

- **A.** neutrons; protons
- **B.** protons; electrons
- **C.** protons; neutrons
- **D.** electrons; protons

---

**11.** Which of the following subatomic particles are closest in mass?

- **A.** neutron and electron
- **B.** electron and ion
- **C.** proton and neutron
- **D.** proton and electron

---

**12.** Elements on the periodic table are organized in order of their

- **A.** Phases of matter.

- **B.** Atomic masses.
- **C.** Atomic numbers.
- **D.** Electronegativities.

---

**13.** Atoms are primarily composed of three types of subatomic particles: protons, neutrons, and electrons.

Where are electrons located in an atom?

- **A.** Their locations vary, depending on the type of atom.
- **B.** They are only located in cellular DNA and nuclei.
- **C.** They are part of the atom's nucleus.
- **D.** They are located outside the atom's nucleus.

---

**14.** How does the average atomic mass of an element differ from the mass of an individual atom of the same element?

- **A.** The average atomic mass of an element is the mass of the most abundant isotope of an element.
- **B.** The masses and relative abundances of all naturally occurring isotopes of the element are required to calculate average atomic mass of the element.
- **C.** The masses and relative abundances of all naturally occurring isotopes of the element are required to calculate the atomic mass of an element.
- **D.** The atomic mass of a single atom of an element can be found on the periodic table of elements.

---

**15.** There are positive, negative, and neutrally-charged particles in atoms. What is the name of the positively-charged particle?

- **A.** electron
- **B.** positron

- **C.** proton
- **D.** neutron

---

**16.** Most of the volume of an atom is taken up by the _____, and most of the mass of an atom is found in the _____.

- **A.** nucleus; nucleus
- **B.** electron clouds; electron clouds
- **C.** nucleus; electron clouds
- **D.** electron clouds; nucleus

---

**17.** If an atom has 4 electrons outside of its nucleus, which combination of protons and neutrons would result in a neutral atom?

- **A.** 1 proton, 3 neutrons
- **B.** 8 protons, 8 neutrons
- **C.** 1 proton, 1 neutron
- **D.** 4 protons, 4 neutrons

---

**18.** The atomic mass of an atom is equal to

- **A.** The total mass of its protons, neutrons, and electrons.
- **B.** The total mass of its protons.
- **C.** The total number of its protons.
- **D.** The total number of its protons and neutrons.

---

**19.** Can the number of protons in an element ever change?

- **A.** Yes, when different elements bond, they can share or transfer protons.
- **B.** No, protons and neutrons are bound together in atomic nuclei, and neither can change.
- **C.** Yes, isotopes of the same element have different numbers of protons.
- **D.** No, if the number of protons changes, the element changes.

---

**20.** A neutral atom always contains the same number of

- **A.** Protons, electrons, and neutrons.
- **B.** Protons and neutrons.
- **C.** Electrons and neutrons.
- **D.** Protons and electrons.

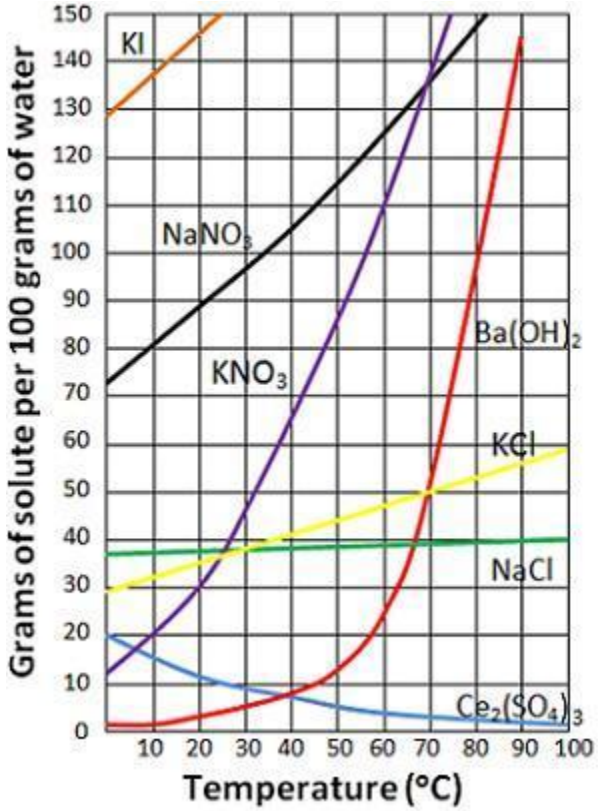
---

## Unit XII Acids and Bases Benchmark Test

---

Select the best answer for each of the following questions:

---




**1.** Examine the above diagram.

Which substance's solubility is affected the least by a change in temperature?

- **A.** NaCl
- **B.** KCl
- **C.** KI
- **D.** $Ce_2(SO_4)_3$

---

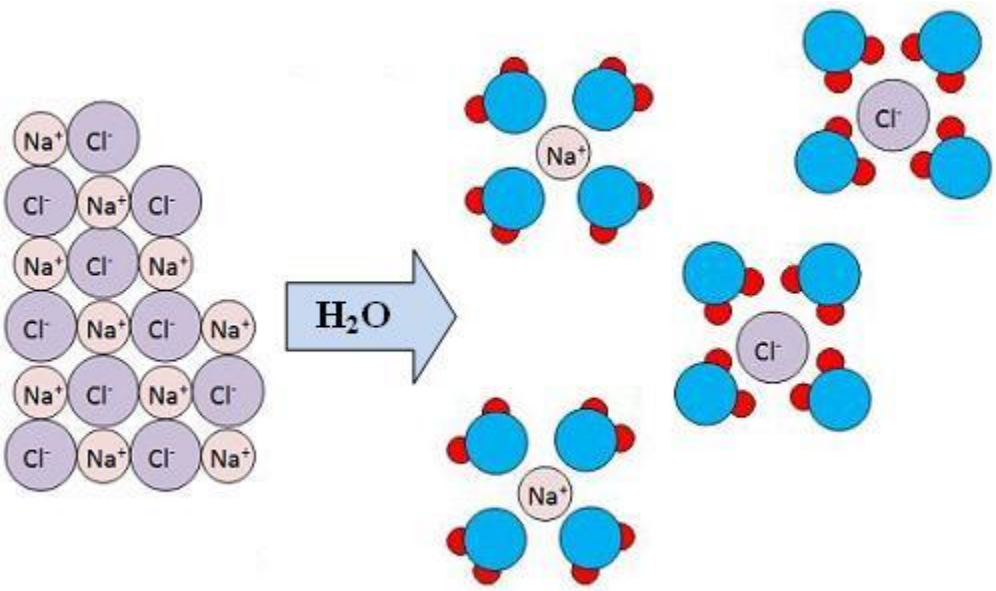
**2.** Which of the following will increase the solubility of a solid?

- **A.** decreasing the surface area of the solid
- **B.** increasing the temperature of the solvent
- **C.** decreasing the volume of the solvent

○ **D.** increasing the amount of the solid

---

**3.** When an ionic solid, such as sodium chloride, is dissolved in water, the following process occurs:




Use the above diagram to determine which of the following statements is true.

○ **A.** The chlorine ions are surrounded by the oxygen sides of the water molecules more than the hydrogen sides.

○ **B.** The sodium ions are surrounded by the oxygen sides of the water molecules more than the hydrogen sides.

○ **C.** Groups of ions are surrounded equally by the oxygen and the hydrogen sides of the water molecules.

○ **D.** The arrangement of water molecules around the sodium and chlorine ions is random and unpredictable.

---

**4.** The table below lists the approximate pHs of a variety of beverages.

| Beverage | pH |
|---|---|

| | |
|---|---|
| coffee | 5.0 |
| milk | 6.3 |
| orange juice | 3.5 |
| soda | 3.0 |
| water | 7.0 |

It has been shown that beverages that are very acidic can wear away the enamel that protects the teeth. Given this information, which of the above beverages would be the best to drink on a regular basis?

- **A.** water
- **B.** milk
- **C.** orange juice
- **D.** coffee

---

**5.** According to Arrhenius, which of the following compounds is an acid?

- **A.** MgBr
- **B.** NaCl
- **C.** HCl
- **D.** LiOH

---

**6.** The term "parts per million" refers to

- **A.** 1 part solvent dissolved in 1,000,000 parts solute.
- **B.** 1 part solute dissolved in 1,000,000 parts solvent.
- **C.** 1 part solute dissolved in 1,000,000,000 parts solvent.
- **D.** 1 part solvent dissolved in 1,000,000,000 parts solute.

---

**7.** Which of the following examples illustrates the physical property of concentration?

- **A.** the amount of space an apple occupies
- **B.** the use of copper to make an electrical wire
- **C.** the amount of lemon juice in a bottle of lemonade
- **D.** a quartz crystal's ability to scratch talc

---

**8.** Litmus paper is often used to determine whether a solution is acidic or alkaline. Which of the following would definitely indicate an acidic solution?

- **A.** red litmus paper turning purple
- **B.** red litmus paper turning blue
- **C.** blue litmus paper turning red
- **D.** blue litmus paper turning purple

---

**9.** The collision model states that reaction rates increase as the number of collisions between particles increases.

Which action would cause the greatest increase in the speed of a chemical reaction?

- **A.** adding a magnetic stirring bar to a reaction mixture
- **B.** rolling a reaction mixture from side to side
- **C.** placing a reaction mixture in an ultrasonic shaker
- **D.** using a plastic rod to slowly stir a reaction mixture

---

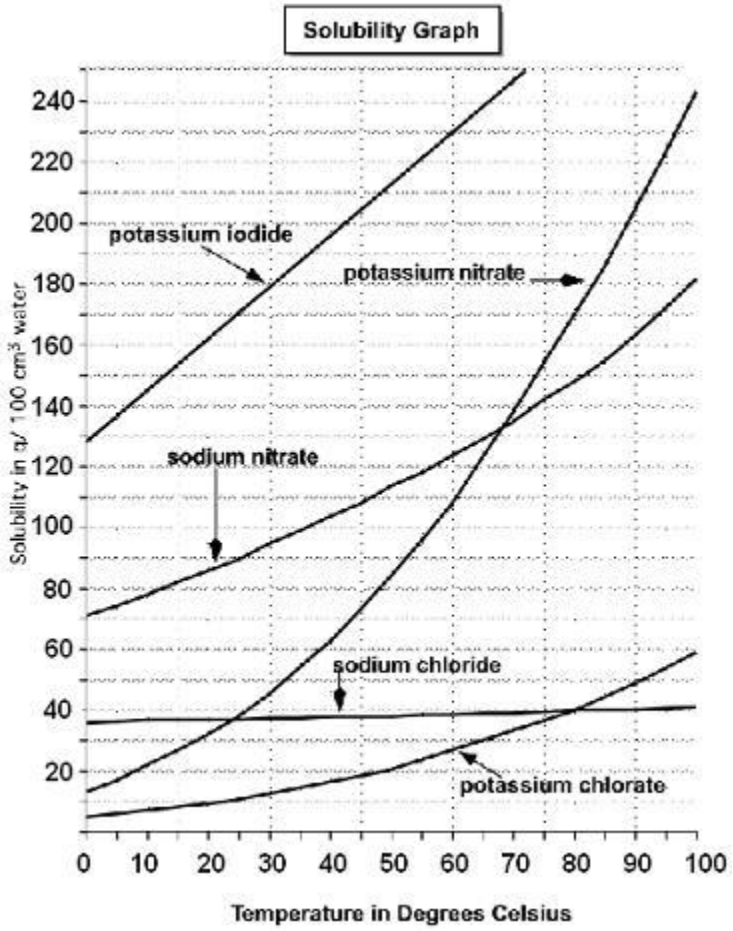
**10.** The concentration of $H^+$ ions in a solution is $1.0 \times 10^{-11}$ M.
What is the pH of the solution?

- **A.** 1.1

- **B.** 11
- **C.** -11
- **D.** 110

---

**11.** Use the diagram below to answer the following question.




What is the solubility of potassium iodide at 30°C?

- **A.** 45 g/100 $cm^3$ of water
- **B.** 180 g/100 $cm^3$ of water
- **C.** 95 g/100 $cm^3$ of water
- **D.** 5 g/100 $cm^3$ of water

---

**12.** Which of the following is a general property of an acid?

- **A.** turns red litmus paper blue
- **B.** tastes sour
- **C.** commonly found in soap
- **D.** feels slippery

---

**13.** Which of the following statements is correct according to the Brønsted-Lowry definition of an acid?

- **A.** Acids release a hydroxide ion and are proton acceptors.
- **B.** Acids release a hydrogen ion and are proton acceptors.
- **C.** Acids release a hydroxide ion and are proton donors.
- **D.** Acids release a hydrogen ion and are proton donors.

---

**14.** When dissolved in water, baking soda, or sodium bicarbonate, can undergo the following reaction.

$$NaHCO_3(s) + H_2O(l) \rightarrow H_2CO_3(aq) + Na^+(aq) + OH^-(aq)$$

This reaction indicates that baking soda is

- **A.** both an acidic and a basic substance.
- **B.** a basic substance.
- **C.** an acidic substance.
- **D.** a neutral substance.

---

**15.** Solutions which contain excess hydrogen ions are considered acidic, while solutions which contain excess hydroxide ions are considered basic.

Neutral solutions contain an equal number of hydrogen and hydroxide ions. Which of the following is an example of a neutral solution?

- **A.** water
- **B.** soda
- **C.** vinegar
- **D.** ammonia

---

**16.** Which of the following changes would increase the concentration of a solution?

- **A.** increasing the temperature
- **B.** increasing the solvent
- **C.** increasing the surface area
- **D.** increasing the solute

---

**17.** Examine the above diagram.

Which substance's solubility decreases with an increase in temperature?

- **A.** KCl
- **B.** $Ce_2(SO_4)_3$
- **C.** $KNO_3$
- **D.** $Ba(OH)_2$

---

**18.** Which of the following best explains why water and oil do not mix?

- **A.** Oil and water are both polar.
- **B.** Water is polar, and oil is non-polar.

- **C.** Oil and water are both non-polar.
- **D.** Water is non-polar, and oil is polar.

---

**19.** Gases are more soluble in liquids when the pressure is increased. However, the solubility of a solid is not affected by changes in pressure. Why is this true?

- **A.** Gases are not compressible, whereas solids are compressible.
- **B.** The solubility of a gas depends on temperature unlike the solubility of solids.
- **C.** Gases are compressible, whereas solids are not compressible.
- **D.** The solubility of a gas does not depend on temperature unlike the solubility of solids.

---

**20.** The following table shows the $pK_a$ values of several acids.

| **Acid** | **$pK_a$** |
|---|---|
| Acetic acid | 4.76 |
| Benzoic acid | 4.20 |
| Hydrochloric acid | -8.00 |
| Perchloric acid | -10.00 |

Which is the strongest acid?

- **A.** Perchloric acid
- **B.** benzoic acid
- **C.** acetic acid
- **D.** hydrochloric acid

**Pre-achievement table**

| Student ID Number | Pre-Achievement score | Gender | Ethnicity | Group | Pretest | Posttest |
|---|---|---|---|---|---|---|
| 1 | 835 | Male | Black | Traditional | 55 | 47 |
| 2 | 833 | Male | Black | Traditional | 41 | 45 |
| 3 | 795 | Female | Black | Traditional | 37 | 58 |
| 4 | 805 | Male | Black | Traditional | 32 | 52 |
| 5 | 790 | Male | Black | Traditional | 43 | 48 |
| 6 | 795 | Male | Black | Traditional | 47 | 37 |
| 7 | 852 | Male | Black | Traditional | 63 | 60 |
| 8 | 819 | Male | Black | Traditional | 53 | 58 |
| 9 | 839 | Male | Black | Traditional | 41 | 54 |
| 10 | 790 | Male | Black | Traditional | 41 | 54 |
| 11 | 877 | Male | Black | Traditional | 73 | 63 |
| 12 | 800 | Male | Black | Traditional | 49 | 54 |
| 13 | 864 | Male | Black | Traditional | 58 | 53 |
| 14 | 810 | Male | Black | Traditional | 45 | 52 |
| 15 | 800 | Male | Black | Traditional | 40 | 45 |
| 16 | 830 | Female | White | Traditional | 48 | 53 |
| 17 | 810 | Female | Black | Traditional | 55 | 67 |
| 18 | 794 | Female | Black | Traditional | 45 | 48 |
| 19 | 843 | Female | Black | Traditional | 60 | 71 |
| 20 | 843 | Female | Hispanic | Traditional | 50 | 49 |
| 21 | 828 | Female | Hispanic | Traditional | 57 | 73 |
| 22 | 828 | Male | White | Traditional | 45 | 55 |
| 23 | 826 | Female | Black | Traditional | 63 | 66 |
| 24 | 869 | Female | White | Traditional | 63 | 83 |

| Student ID Number | Pre-Achievement score | Gender | Ethnicity | Group | Pretest | Posttest |
|---|---|---|---|---|---|---|
| 25 | 830 | Male | Black | Traditional | 52 | 49 |
| 26 | 775 | Female | Black | Traditional | 47 | 49 |
| 27 | 839 | Female | Asian | Traditional | 54 | 59 |
| 28 | 804 | Male | Black | Traditional | 42 | 49 |
| 29 | 762 | Male | Black | Traditional | 36 | 55 |
| 30 | 898 | Female | White | Traditional | 52 | 57 |
| 31 | 854 | Female | Black | Traditional | 71 | 64 |
| 32 | 801 | Male | Black | Traditional | 40 | 53 |
| 33 | 792 | Female | Black | Traditional | 48 | 54 |
| 34 | 805 | Male | Black | Traditional | 47 | 56 |
| 35 | 801 | Female | Black | Traditional | 49 | 51 |
| 36 | 824 | Female | Black | Traditional | 52 | 65 |
| 37 | 839 | Male | Black | Traditional | 42 | 46 |
| 38 | 821 | Male | Black | Traditional | 33 | 31 |
| 39 | 811 | Female | Black | Traditional | 38 | 52 |
| 40 | 783 | Female | Black | Traditional | 35 | 53 |
| 41 | 795 | Male | Black | Traditional | 42 | 30 |
| 42 | 805 | Male | Black | Traditional | 44 | 51 |
| 43 | 864 | Male | Black | Traditional | 46 | 45 |
| 44 | 826 | Female | White | Traditional | 38 | 46 |
| 45 | 894 | Female | Black | Traditional | 63 | 67 |
| 46 | 820 | Male | Hispanic | Traditional | 60 | 59 |
| 47 | 850 | Female | Black | Traditional | 62 | 71 |
| 48 | 833 | Male | Black | Traditional | 50 | 56 |
| 49 | 795 | Male | Black | Traditional | 35 | 70 |
| 50 | 775 | Female | Black | Traditional | 43 | 55 |

| Student ID Number | Pre-Achievement score | Gender | Ethnicity | Group | Pretest | Posttest |
|---|---|---|---|---|---|---|
| 1 | 835 | Male | Black | Virtual | 47 | 70 |
| 2 | 833 | Male | Black | Virtual | 37 | 31 |
| 3 | 795 | Female | Black | Virtual | 37 | 59 |
| 4 | 805 | Male | Black | Virtual | 44 | 56 |
| 5 | 790 | Male | Black | Virtual | 31 | 59 |
| 6 | 795 | Male | Black | Virtual | 38 | 56 |
| 7 | 852 | Male | Black | Virtual | 43 | 77 |
| 8 | 819 | Male | Black | Virtual | 33 | 68 |
| 9 | 839 | Male | Black | Virtual | 37 | 58 |
| 10 | 790 | Male | Black | Virtual | 37 | 78 |
| 11 | 877 | Male | Black | Virtual | 51 | 59 |
| 12 | 800 | Male | Black | Virtual | 46 | 65 |
| 13 | 864 | Male | Black | Virtual | 59 | 60 |
| 14 | 810 | Male | Black | Virtual | 40 | 54 |
| 15 | 800 | Male | Black | Virtual | 37 | 60 |
| 16 | 830 | Female | White | Virtual | 48 | 37 |
| 17 | 810 | Female | Black | Virtual | 48 | 43 |
| 18 | 794 | Female | Black | Virtual | 29 | 48 |
| 19 | 843 | Female | Black | Virtual | 55 | 76 |
| 20 | 843 | Female | Hispanic | Virtual | 37 | 45 |
| 21 | 828 | Female | Hispanic | Virtual | 54 | 61 |
| 22 | 828 | Male | White | Virtual | 42 | 62 |
| 23 | 826 | Female | Black | Virtual | 55 | 75 |
| 24 | 869 | Female | White | Virtual | 53 | 65 |
| 25 | 830 | Male | Black | Virtual | 33 | 62 |
| 26 | 775 | Female | Black | Virtual | 36 | 59 |

| Student ID Number | Pre-Achievement score | Gender | Ethnicity | Group | Pretest | Posttest |
|---|---|---|---|---|---|---|
| 27 | 839 | Female | Asian | Virtual | 54 | 43 |
| 28 | 804 | Male | Black | Virtual | 41 | 65 |
| 29 | 762 | Male | Black | Virtual | 37 | 46 |
| 30 | 898 | Female | White | Virtual | 42 | 57 |
| 31 | 854 | Female | Black | Virtual | 50 | 63 |
| 32 | 801 | Male | Black | Virtual | 36 | 55 |
| 33 | 792 | Female | Black | Virtual | 23 | 53 |
| 34 | 805 | Male | Black | Virtual | 46 | 63 |
| 35 | 801 | Female | Black | Virtual | 35 | 59 |
| 36 | 824 | Female | Black | Virtual | 38 | 69 |
| 37 | 839 | Male | Black | Virtual | 47 | 54 |
| 38 | 821 | Male | Black | Virtual | 39 | 61 |
| 39 | 811 | Female | Black | Virtual | 28 | 39 |
| 40 | 783 | Female | Black | Virtual | 39 | 55 |
| 41 | 795 | Male | Black | Virtual | 24 | 47 |
| 42 | 805 | Male | Black | Virtual | 39 | 51 |
| 43 | 864 | Male | Black | Virtual | 32 | 61 |
| 44 | 826 | Female | White | Virtual | 44 | 42 |
| 45 | 894 | Female | Black | Virtual | 51 | 61 |
| 46 | 820 | Male | Hispanic | Virtual | 202 | 69 |
| 47 | 850 | Female | Black | Virtual | 60 | 58 |
| 48 | 833 | Male | Black | Virtual | 46 | 59 |
| 49 | 795 | Male | Black | Virtual | 50 | 61 |
| 50 | 775 | Female | Black | Virtual | 40 | 57 |